Environmental Studies No. 56

Mackenzie Environmental Monitoring Project — Phase II 1987 Activities

Northern Affairs Program

LGL Limited
ESSA Environmental and
Social Systems Analysts Limited
Lutra Associates
ESL Environmental Sciences Limited
Seakem Oceanography Limited
P.J. Usher Consulting Services
Renewable Resources Consulting
M. Miles and Associates Limited
A. Gell

Published under the authority of the
Hon. Bill McKnight, P.C., M.P.,
Minister of Indian Affairs and
Northern Development,
Ottawa, 1988.

QS-8424-000-EF-A1
Catalogue No. R71-19/56-1988E
ISBN 0-662-16577-2

©Minister of Supply and Services Canada

This Report was prepared under contract for the Northern Oil and Gas Action Program (NOGAP), Natural Resources and Economic Development Branch, Department of Indian Affairs and Northern Development.

The views, conclusions and recommendations expressed herein are those of the authors and not necessarily those of the Department.

Indian and Northern
Affairs Canada

Affaires indiennes
et du Nord Canada

90-04554/

ACKNOWLEDGMENTS

The Mackenzie Environmental Monitoring Project relies on the cooperation and contributions of a number of scientists and managers from government agencies, the petroleum industry, universities and consulting firms as well as individuals from the communities. We acknowledge all participants who contributed to this project. In particular, the following individuals and organizations are thanked for their contributions:

Albert Adams	Mackenzie Delta Regional Council, Inuvik
Jim Allard	Metis Association, Fort Good Hope
Alex Aviugana	Inuvialuit Game Council, Inuvik
Maurice Mendo	Great Bear DIZ Society, Fort Norman
Jim Pierrot	Mackenzie/Great Bear DIZ Society, Norman Wells
George Edwards	Hunters and Trappers Association, Aklavik
Albert Elias	Holman Island
David Krutko	Mackenzie Delta Regional Council
John McCallum	Dene Nation, Yellowknife
Alice Able	Dene Nation, Yellowknife
Mike Fabijan	Inuvialuit Joint Secretariat, Inuvik
Kevin Lloyd	NWT Department Renewable Resources, Yellowknife
Jamie Bastedo	NWT Department Renewable Resources, Yellowknife
Bob Bromley	NWT Department Renewable Resources, Yellowknife
Bob Decker	NWT Department Renewable Resources, Yellowknife
Steve Matthews	NWT Department Renewable Resources, Yellowknife
Mitch Taylor	NWT Department Renewable Resources, Yellowknife
Kim Poole	NWT Department Renewable Resources, Yellowknife
Chris Shank	NWT Department Renewable Resources, Yellowknife
Larry Hagen	NWT Department Renewable Resources, Yellowknife
Dyan Grant-Francis	NWT Department Renewable Resources, Yellowknife
Steve Moore	NWT Department Renewable Resources, Yellowknife
Rus Hall	NWT Department Renewable Resources, Yellowknife
Doug Heard	NWT Department Renewable Resources, Yellowknife
Peter Clarkson	NWT Department Renewable Resources, Yellowknife
Gordon Stenhouse	NWT Department Renewable Resources, Inuvik
Randal Glaholt	NWT Department Renewable Resources, Inuvik
Ron Graf	NWT Department Renewable Resources, Inuvik
Jennett Frost	NWT Department Renewable Resources, Fort Smith
Sheldon Nyder	NWT Department Social Services
Susan Fleck	NWT Department Social Services
Gay Kennedy	NWT Science Institute, Yellowknife
Debbie Delancy	NWT Energy, Mines and Resources, Yellowknife
Rick Hurst	NWT Priorities and Planning, Yellowknife
Kay McInnes	INAC, Yellowknife
Greg Cook	INAC, Yellowknife
Hal Mills	INAC, Yellowknife
David Moll	INAC, Yellowknife
Wayne Balanoff	INAC, Yellowknife

Lorne Tricoteux	INAC, Yellowknife
Donna Stewart	INAC, Ottawa
Ben Hubert	Boreal Ecology Services, Yellowknife
Barry Connacher	Barcon, Yellowknife
Harvey Jessup	Yukon Department Renewable Resources, Whitehorse
Dave Mossop	Yukon Department Renewable Resources, Whitehorse
George Mackenzie-Grieve	EPS, Whitehorse
Anita Moore	Boreal Institute, University of Alberta, Edmonton
Tom Andrew	Dene Mapping Project, University of Alberta, Edmonton
Lois Harwood	Fisheries Joint Management Committee, Inuvik
Kevin McCormick	CWS, Yellowknife
Lynn Dickson	CWS, Edmonton
Stuart Alexander	CWS, Edmonton
Peter Boothroyd	CWS, Winnipeg
Jim Hawkings	CWS, Whitehorse
Brian Wong	DFO, Yellowknife
Vic Gilman	DFO, Inuvik
Bill Bond	DFO, Winnipeg
Michael Lawrence	DFO, Winnipeg
Jim Reist	DFO, Winnipeg
Ken Chang-Kue	DFO, Winnipeg
Allen Kristofferson	DFO, Winnipeg
George McKinnon	DFO, Winnipeg
Tom Strong	DFO, Winnipeg
Mike Kingsley	DFO, Winnipeg
Ian Birtwell	DFO, Vancouver
Terry Day	Sediment Survey of Canada, Ottawa
Peter Lewis	C.P. Lewis and Associates, Victoria
Bob Bradley	B.C. Hydro Authority, Vancouver
Stu Davies	North South Consulting, Winnipeg
Archie Pick	Interprovincial Pipelines (N.W.) Ltd., Edmonton
Don Wishart	Interprovincial Pipelines (N.W.) Ltd., Edmonton
Bob Mahnic	Interprovincial Pipelines (N.W.) Ltd., Edmonton
Cal Sikstrom	ESSO Resources Canada Limited, Edmonton
Terry Antoniuk	Gulf Canada Resources Ltd., Calgary
Ed Pessah	Dome Petroleum, Calgary
Ken Taylor	Polar Gas, Toronto

The actual preparation of this report was a joint effort by several firms, as shown below. Technical assistance during report production at LGL Limited was provided by Jill Peterson and Nell Stallard; Lisa Clark did all the final word processing.

Discipline	Contributor
Hydrocarbon Development Scenarios	W. Duval ESL Environmental Sciences Limited Vancouver, B.C.
Terrestrial and Semi-Aquatic Mammals	G. Searing LGL Ltd. Sidney, B.C.
Caribou	R. Jakimchuk and L. Sopuck Renewable Resources Consulting Services Ltd. Sidney, B.C.
Birds	S. Johnson LGL Ltd., Sidney, B.C.
Fish and Lower Trophic Levels	A. Sekerak LGL Ltd., Sidney, B.C.
Oceanography, Climatology and Air Quality	J. McDonald ESL Environmental Sciences Limited Sidney, B.C.
Water Quality	D. Thomas Seakem Oceanography Ltd. Sidney, B.C.
Hydrology	M. Miles M. Miles and Associates Ltd. Victoria, B.C.
Terrain Subsidence	A. Gell Sooke, B.C.
Resource Harvesting	L. Little and R. Stephen Lutra Associates, Yellowknife, NWT
Resource Harvesting	R. Everitt ESSA Environmental and Social Systems Analysts Ltd., Vancouver, B.C.
Resource Harvesting	P. Usher P.J. Usher Consulting Services, Ottawa, Ontario

TABLE OF CONTENTS

PAGE

ACKNOWLEDGMENTS i

LIST OF TABLES xviii

LIST OF FIGURES xix

SOMMAIRE xxi

INTRODUCTION 1

BACKGROUND 1

- Impact Hypotheses 2
- Monitoring 3
- Adaptive Environmental Assessment and Management 3

ACTIVITIES IN 1987 4

- Methods 5
- Report Organization 5

PART I: AN UPDATED HYDROCARBON DEVELOPMENT SCENARIO FOR THE MEMP STUDY AREA

INTRODUCTION 7

RECENT ACTIVITIES OF THE OIL AND GAS INDUSTRY 7

FUTURE DEVELOPMENT SCENARIO 8

- Exploration and Production Drilling 8
- Oil and Gas Processing Facilities and Gathering Line Systems 11
- Transport Systems 11
- Support Systems 12

PART II: PERTINENT RESEARCH IN RELATION TO MEMP HYPOTHESES

INTRODUCTION 14

HYPOTHESIS NO. 1 The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the numbrers of arctic and red foxes 15

MEMP PROJECT OVERVIEW NO. 1-1: Observations on foxes, Alopex lagopus and Vulpes vulpes, and wolves, Canis lupus, on the off-shore sea ice of northern Labrador 18

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 1-2: Arctic fox den survey - Herschel Island, July 24-28, 1986 19

MEMP PROJECT OVERVIEW NO. 1-3: Physical characteristics, terrain associations and soil properties of arctic fox (Alopex lagopus) dens in northern Yukon Territory, Canada 20

MEMP PROJECT OVERVIEW NO. 1-4: Lisburne Terrestrial Monitoring Program - 1986. The effects of the Lisburne Development Project on geese and swans 21

MEMP PROJECT OVERVIEW NO. 1-5: Ecological factors influencing the distribution of ringed seals during the open water period in the southeastern Beaufort Sea 22

MEMP PROJECT OVERVIEW NO. 1-6: Distribution and abundance of seals in the Beaufort Sea, Amundsen Gulf and Prince Albert Sound, 1984 23

MEMP PROJECT OVERVIEW NO. 1-7: Tagging and movements of polar bears in the Beaufort Sea 24

MEMP PROJECT OVERVIEW NO. 1-8: Attraction of polar bears to offshore rigs 25

HYPOTHESIS NO. 2: Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution 27

MEMP PROJECT OVERVIEW NO. 2-1: Migratory movements and the Nelchina caribou herd in relation to the Trans-Alaska pipeline 30

MEMP PROJECT OVERVIEW NO. 2-2: Differential habitat use and sexual segregation of the Central Arctic caribou herd 31

MEMP PROJECT OVERVIEW NO. 2-3: The relationship of caribou summer distribution and the Trans-Alaska Pipeline: does absence mean displacement? 32

MEMP PROJECT OVERVIEW NO. 2-4: Dynamics of caribou and wolves in Denali National Park 33

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 2-5: Movement patterns of the Porcupine caribou herd in relation to oil development 34

MEMP PROJECT OVERVIEW NO. 2-6: Daily energy budgets of caribou: a simulation approach 35

MEMP PROJECT OVERVIEW NO. 2-7: Effects of a road system on caribou distribution during calving 36

MEMP PROJECT OVERVIEW NO. 2-8: The effects of pipelines, roads and traffic on the movements of caribou (*Rangifer tarandus*) 37

MEMP PROJECT OVERVIEW NO. 2-9: Oil pipeline crossing sites utilized in winter by moose, (*Alces alces*) and caribou (*Rangifer tarandus*) in southcentral Alaska 39

MEMP PROJECT OVERVIEW NO. 2-10: Influence of the Dempster Highway on the activity of the Porcupine caribou herd 41

MEMP PROJECT OVERVIEW NO. 2-11: Movement and behaviour of the Burwash caribou herd relative to the proposed Alaska Highway Gas Pipeline 42

MEMP PROJECT OVERVIEW NO. 2-12: Distribution of caribou calving in relation to the Prudhoe Bay oilfield 43

MEMP PROJECT OVERVIEW NO. 2-13: Factors affecting pipeline crossing success of caribou 44

MEMP PROJECT OVERVIEW NO. 2-14: Reactions of large groups of caribou to a pipeline corridor on the Arctic coastal plain of Alaska 45

MEMP PROJECT OVERVIEW NO. 2-15: Effects of the Trans-Alaska pipeline on the distribution and movements of caribou 46

MEMP PROJECT OVERVIEW NO. 2-16: The buffalo of the North: caribou (*Rangifer tarandus*) and human developments 48

MEMP PROJECT OVERVIEW NO. 2-17: Responses of caribou to ramps and pipelines in the west end of the Kuparuk Oilfield, Alaska, 1983 49

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 2-18: Caribou use of ramps for crossing pipe/road complexes, Kuparuk Oilfield, Alaska, 1984 51

MEMP PROJECT OVERVIEW NO. 2-19: Caribou movement along the Oliktok Road and in the Kalubik Creek region, Kuparuk Oilfield, Alaska, 1983 53

MEMP PROJECT OVERVIEW NO. 2-20: Movements and activity budgets of caribou near oil drilling sites in the Sagavanirktok River floodplains, Alaska 54

MEMP PROJECT OVERVIEW NO. 2-21: Caribou responses to the pipeline/road complex in the Kuparuk Oil Field, Alaska, 1981 56

HYPOTHESIS NO. 3: Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution 57

MEMP PROJECT OVERVIEW NO. 3-1: A review of northern grizzly bear ecology and habitat mapping techniques 60

MEMP PROJECT OVERVIEW NO. 3-2: Grizzly bear conservation and management: a review 61

MEMP PROJECT OVERVIEW NO. 3-3: Monitoring grizzly bear population trends 62

MEMP PROJECT OVERVIEW NO. 3-4: Industrial effects on grizzly bear denning and habitat use on Richards Island 63

HYPOTHESIS NO. 4: Oil and gas development activities will alter the water regime and decrease muskrat populations 65

MEMP PROJECT OVERVIEW NO. 4-1: The effect of water level fluctuations on muskrat (Ondatra aibethicus), predation by mink (Mustela vison) 68

MEMP PROJECT OVERVIEW NO. 4-2: Quantitative synthesis of the Mackenzie Delta ecosystem 69

MEMP PROJECT OVERVIEW NO. 4-3: Lake regimes, Mackenzie Delta, N.W.T., 1982, 1983 and 1984 71

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 4-4: Mackenzie Delta environmental hydrology 72

MEMP PROJECT OVERVIEW NO. 4-5: The distribution and ecology of the shoreline vegetation on the Mackenzie Delta, N.W.T. 73

MEMP PROJECT OVERVIEW NO. 4-6 Quantitative synthesis of the Mackenzie Delta ecosystem 74

MEMP PROJECT OVERVIEW NO. 4-7: Muskrat push-up surveys in the Mackenzie Delta May 1981 and 1982 75

MEMP PROJECT OVERVIEW NO. 4-8: The distribution and ecology of the shoreline vegetation on the Mackenzie Delta, N.W.T. 76

HYPOTHESIS NO. 5: Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose 77

MEMP PROJECT OVERVIEW NO. 5-1: Oil pipeline crossing sites utilized in winter by moose (*Alces alces*) and caribou (*Rangifer tarandus*) in South Central Alaska 80

MEMP PROJECT OVERVIEW NO. 5-2: Seasonal foraging rates of free-ranging moose 81

MEMP PROJECT OVERVIEW NO. 5-3: Estimates of digestibility of birch, willow and aspen mixtures in moose 82

MEMP PROJECT OVERVIEW NO. 5-4: Winter activity patterns of moose in interior Alaska 83

MEMP PROJECT OVERVIEW NO. 5-5: Revegetation monitoring of the Interprovincial Pipeline (NW) Ltd., Norman Wells to Zama pipeline 84

MEMP PROJECT OVERVIEW NO. 5-6: Effects of winter seismic exploration on the coastal plain, Arctic National Wildlife Refuge, Alaska, 1984 86

MEMP PROJECT OVERVIEW NO. 5-7: Wildlife monitoring studies along the Norman Wells - Zama Oil Pipeline, November 1984 to May 1987 88

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 5-8: Long term evaluation of revegetation and restoration, Norman Wells Pipeline 89

HYPOTHESIS NO. 6: Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten 91

MEMP PROJECT OVERVIEW NO. 6-1: Responses of small mammals to forest harvesting in northern Maine 94

MEMP PROJECT OVERVIEW NO. 6-2: Winter habitat use, food habits and home range size of the marten (Martes americana) in western Newfoundland 95

MEMP PROJECT OVERVIEW NO. 6-3: Microtines and ground squirrels of the coastal plain of the Arctic National Wildlife Refuge: notes on distributions, densities and general ecology 96

HYPOTHESIS NO. 7: Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl 97

MEMP PROJECT OVERVIEW NO. 7-1: Influence of the Norman Wells Oilfield Expansion Project on snow geese 100

Resolving production drilling restrictions and waterfowl disturbance concerns during spring migration at Norman Wells, Northwest Territories, Canada 100

Spring use of the Mackenzie River by snow geese in relation to the Norman Wells Oilfield Expansion Project 100

MEMP PROJECT OVERVIEW NO. 7-2: Behaviour of Pacific black brant and other geese in response to aircraft overflights and other disturbances at Izembek Lagoon, Alaska 1987 102

Behaviour of Pacific black brant and other geese in response to aircraft overflights and other disturbances at Izembek Lagoon, Alaska 1986 102

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 7-3: Preliminary assessment of the effects of the proposed Polar Gas pipeline and other hydrocarbon development projects on waterfowl of the northern Mackenzie Valley 104

MEMP PROJECT OVERVIEW NO. 7-4: Initial environmental evaluation of low-level military training flights in the Northwest Territories, Alberta and Saskatchewan-IR 920 105

Initial environmental evaluation of low-level military training flights in British Columbia-IR 910 105

MEMP PROJECT OVERVIEW NO. 7-5: Key areas for birds in coastal regions of the Canadian Beaufort Sea 107

HYPOTHESIS NO. 8: Disturbance and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species 109

MEMP PROJECT OVERVIEW NO. 8-1: Initial environmental evaluation of low-level military training flights in the Northwest Territories, Alberta and Saskatchewan-IR 920 112

Initial environmental evaluation of low-level military training flights in British Columbia-IR 910 112

MEMP PROJECT OVERVIEW NO. 8-2: Raptor monitoring program, Norman Wells Pipeline Project, 1987 progress report 114

Raptor monitoring program, Norman Wells Pipeline Project, 1986 progress report 114

Raptor monitoring program, Norman Wells Pipeline Project, 1985 progress report 114

Raptor monitoring program, Norman Wells Pipeline Project, 1984 progress report 115

HYPOTHESIS NO. 9: The presence of camps and garbage disposal sites will attract predators that will lead to changes in local abundance and distribution of waterfowl 116

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 9-1: Lisburne terrestrial monitoring program - 1985; the effects of the Lisburne Development Project on geese and swans 118

Lisburne terrestrial monitoring program - 1986; the effects of the Lisburne Development Project on geese and swans 118

MEMP PROJECT OVERVIEW NO. 9-2: Key areas for birds in coastal regions of the Canadian Beaufort Sea 121

HYPOTHESIS NO. 10: Chronic (episodic) spills of crude oil and diesel fuel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl 123

MEMP PROJECT OVERVIEW NO. 10-1: A hazard assessment of chemically dispersed oil spills and seabirds 125

MEMP PROJECT OVERVIEW NO. 10-2: Ecological characteristics of 35-year-old crude oil spills in tundra plant communities of the Mackenzie Mountains, N.W.T. 126

MEMP PROJECT OVERVIEW NO. 10-3: Key areas for birds in coastal regions of the Canadian Beaufort Sea 127

HYPOTHESIS NO. 11: Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat 129

MEMP PROJECT OVERVIEW NO. 11-1: Geotechnical and geothermal conditions of nearshore sediments, southern Beaufort Sea, N.W.T. 132

MEMP PROJECT OVERVIEW NO. 11-2: Massive ground ice associated with glaciofluvial sediments, Richards Island, N.W.T. 133

MEMP PROJECT OVERVIEW NO. 11-3: Mackenzie Delta sedimentary environments and processes 134

HYPOTHESIS NO. 12: Air emissions resulting from oil and gas development and operation will adversely affect air quality 136

TABLE OF CONTENTS (cont'd)

Page

HYPOTHESIS NO. 13: Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish quality 138

HYPOTHESIS NO. 14: Improved access and fishing pressure will decrease the abundance of fish and affect their distribution 140

MEMP PROJECT OVERVIEW NO. 14-1: Biological data on Arctic Charr, _Salvelinus alpinus_ (L.), from the Rat River, Northwest Territories, 1983 142

MEMP PROJECT OVERVIEW NO. 14-2: Arctic charr population studies: 1. Big Fish River; 2. river system survey 1984 (Yukon coast east to Victoria Island) 143

MEMP PROJECT OVERVIEW NO. 14-3: Data from the monitoring of domestic/commercial fisheries for Arctic charr in the Big Fish River and Rat River areas, Northwest Territories 1986 144

MEMP PROJECT OVERVIEW NO. 14-4: Broad whitefish stock differentiations 145

MEMP PROJECT OVERVIEW NO. 14-5: Fishery data from Phillips Bay, Yukon, 1985 146

MEMP PROJECT OVERVIEW NO. 14-6: Fish distribution and abundance along the Yukon coast 147

MEMP PROJECT OVERVIEW NO. 14-7: External scarring of whitefish, _Coregonus nasus_ and _C. clupeaformis_ complex, from the western Northwest Territories, Canada 149

HYPOTHESIS NO. 15: Waste discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source 151

MEMP PROJECT OVERVIEW NO. 15-1: The flux of suspended particulates, petroleum related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: a pilot study of the East Channel 156

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 15-2: Assessment of freshwater impacts from the Norman Wells Oilfield Development. Part III 158

MEMP PROJECT OVERVIEW NO. 15-3: Assessment of freshwater impacts from the Norman Wells Oilfield Development. Part IV 160

MEMP PROJECT OVERVIEW NO. 15-4: Geological assessment of waste drilling fluid contaminant sites in the Mackenzie River valley region, N.W.T. 161

MEMP PROJECT OVERVIEW NO. 15-5: Studies to determine whether the condition of fish from the Lower Mackenzie River is related to hydrocarbon exposure 163

MEMP PROJECT OVERVIEW NO. 15-6: Recommended laboratory methods for assessment of fish quality 165

HYPOTHESIS NO. 16: The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success 167

MEMP PROJECT OVERVIEW NO. 16-1: Water quality and biological survey of five streams in the vicinity of Stokes Point, Yukon-Beaufort Sea coast 170

MEMP PROJECT OVERVIEW NO. 16-2: Broad whitefish migratory patterns and critical areas 171

MEMP PROJECT OVERVIEW NO. 16-3: The effect of winter pipeline construction on the fishes and fish habitat of Hodgson Creek, N.W.T. 172

MEMP PROJECT OVERVIEW NO. 16-4: The effects of winter oil pipeline construction on the benthic macroinvertebrate community structure of Hodgson Creek, N.W.T. 174

MEMP PROJECT OVERVIEW NO. 16-5: Fish passage assessment of culverts constructed to simulate stream conditions on Liard River tributaries 176

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 16-6: Responses of Arctic grayling (Thymallus arcticus) to acute and prolonged exposure to Yukon placer mining sediment 177

MEMP PROJECT OVERVIEW NO. 16-7: Western arctic fish collections 1983-1986: sample-processing procedures and basic data on individual specimens 178

MEMP PROJECT OVERVIEW NO. 16-8: Aquatic monitoring survey, Norman Wells to Zama pipeline, July 1985 179

MEMP PROJECT OVERVIEW NO. 16-9: Aquatic monitoring survey, Norman Wells to Zama pipeline, July 1986 180

MEMP PROJECT OVERVIEW NO. 16-10: Aquatic monitoring studies of Norman Wells to Zama Oil pipeline, 1984-1987 181

MEMP PROJECT OVERVIEW NO. 16-11: Water quality monitoring in relation to 1984 pipeline construction 185

MEMP PROJECT OVERVIEW NO. 16-12: Water quality monitoring in relation to 1985 pipeline construction and operation 186

MEMP PROJECT OVERVIEW NO. 16-13: Norman Wells Pipeline Project 1985 report on monitoring of construction and operation 187

MEMP PROJECT OVERVIEW NO. 16-14: Norman Wells Pipeline Project 1986 report on monitoring of construction and operation 188

MEMP PROJECT OVERVIEW NO. 16-15: Norman Wells Pipeline Project 1987 Report on monitoring of construction and operation 189

MEMP PROJECT OVERVIEW NO. 16-16: Deep scour holes on the bed of Mackenzie Delta channels, N.W.T. 190

MEMP PROJECT OVERVIEW NO. 16-17: Mackenzie Delta channel dynamics: miscellaneous data 191

MEMP PROJECT OVERVIEW NO. 16-18: Assessment of problems related to the source, transfer and fate of sediment along the Mackenzie River, N.W.T. 192

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 16-19: Sediment transfer along Mackenzie River: a feasibility study 193

HYPOTHESIS NO. 17: Wolverines that are attracted to camps and garbage will be killed as nuisance animals, thus reducing the population 194

HYPOTHESIS NO. 18: Wage employment will change the harvest of white whales 197

MEMP PROJECT OVERVIEW NO. 18-1: The effects of rotational wage employment on families and workers in the Beaufort - Mackenzie Delta area 200

MEMP PROJECT OVERVIEW NO. 18-2: Annual Canada benefits submissions 202

MEMP PROJECT OVERVIEW NO. 18-3: Harvest statistics: Mackenzie Estuary beluga hunt 1985, 1986, 1987 203

MEMP PROJECT OVERVIEW NO. 18-4: Harvest study, Inuvialuit Game Council 1987/88 204

MEMP PROJECT OVERVIEW NO. 18-5: Identification of impact indicators for renewable resource harvesting 205

MEMP PROJECT OVERVIEW NO. 18-6: A review of renewable resource impacts and mitigation measures related to northern hydrocarbon development 207

MEMP PROJECT OVERVIEW NO. 18-7: The Dene experience with the Norman Wells Pipeline Project mid-term evaluation, September 1985 209

MEMP PROJECT OVERVIEW NO. 18-8: Canadian Oil and Gas Lands Administration, call for proposals Number 86 N.W.T. - 1 Schedule 11: Community participation and local and northern benefits, Chevron Canada Resources Ltd. 210

MEMP PROJECT OVERVIEW NO. 18-9: Historical harvest summary for general hunting licence holders in the Fort Smith and Inuvik regions, Northwest Territories from 1931/32 through 1984/85 211

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 18-10: A downstream perspective: Dene concerns with the environmental assessment, monitoring and surveillance of the Norman Wells Project with particular reference to fish and water quality 212

HYPOTHESIS NO. 19: Vessel traffic will decrease the harvest of white whales 213

MEMP PROJECT OVERVIEW NO. 19-1: 1986 Arctic industrial activities compilation for the Canadian Beaufort Sea: seismic surveys, vessel movements, aircraft traffic and offshore marine research 215

HYPOTHESIS NO. 20: Competition by non-locals will change the number of white whales landed and increase mortality in the population 217

HYPOTHESIS NO. 21: Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to a reduction in the number and alter the distribution of waterfowl 219

HYPOTHESIS NO. 22: Increased levels of wage employment will change the total annual harvest of resources by communities in the region 221

MEMP PROJECT OVERVIEW NO. 22-1: Dene Gondie Study: Dene National perceptions of the impacts of the Norman Wells Project 224

MEMP PROJECT OVERVIEW NO. 22-2: Individual trapping - record summary ... 226

MEMP PROJECT OVERVIEW NO. 22-3: Socio-economic monitoring report 1985, Norman Wells to Zama Pipeline project 227

HYPOTHESIS NO. 23: Changes in access will alter the harvest of birds, fish and mammals 229

MEMP PROJECT OVERVIEW NO. 23-1: Community renewable resource harvest maps 232

TABLE OF CONTENTS (cont'd)

Page

MEMP PROJECT OVERVIEW NO. 23-2: Porcupine caribou harvest by Canadian users progress report to the Porcupine Caribou Management Board June 1986 - December 1986 233

HYPOTHESIS NO. 24: Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use 234

MEMP PROJECT OVERVIEW NO. 24-1: Dene mapping project 236

MEMP PROJECT OVERVIEW NO. 24-2: An evaluation of the Norman Wells Project by the Department of Renewable Resources, Government of the Northwest Territories 237

HYPOTHESIS NO. 25: Increases in hunting by non-locals will restrict harvest by local natives 239

MEMP PROJECT OVERVIEW NO. 25-1: Summary of 1984/85, 1985/86, 1986/87 Resident Hunter Harvest Survey 242

MEMP PROJECT OVERVIEW NO. 25-2: Norman Wells socio-economic impact monitoring report, Summary report 1-86 243

PART III: **RECOMMENDATIONS FOR NEW HYPOTHESES OR REVISIONS OF CURRENT HYPOTHESES AND MONITORING PROGRAMS** 245

Biophysical Hypotheses: No's 1-17 245

Hypothesis 2: Traffic and Caribou 245
Hypothesis 4: Water Level and Muskrats 245
Hypothesis 5: Habitat Changes and Moose 247
Hypothesis 11: Land Subsidence 247
Hypothesis 14: Improved Access and Fish Harvest 247

Resource Harvesting Hypotheses: No.'s 18-25 247

Background 247
Overview of Project Summaries 248
Revisions to Monitoring Programs 248
Revisions to Hypotheses 249
The Mismatch of Biophysical Hypotheses and the Resource Harvesting Hypotheses 249

LITERATURE CITED 253

LIST OF TABLES

Table		Page
1	Additional discoveries of hydrocarbons	9
2	Additional exploration and production wells	9
3	Recommendations for revisions of existing MEMP biophysical hypotheses (1-17) and needs for new hypotheses	246
4	A summary of the 9 major components that are addressed in each resource harvesting hypothesis	250
5	The number of overviews that address each of the 9 major components of the resource harvesting hypotheses	251
6	Recommended revisions to Hypotheses 18-25 and associated monitoring programs	252

LIST OF FIGURES

Figure Page

1 Boundaries of the MEMP study area 6

2 Hydrocarbon discovery locations 10

SOMMAIRE

Au cours de l'année 1983, Affaires indiennes et du Nord Canada et Environnement Canada ont lancé le Projet de surveillance de l'environnement dans la mer de Beaufort (PSEMB). Ce projet vise à fournir les données techniques nécessaires à la conception, à l'exécution et à l'évaluation d'un programme complet et réalisable de recherche et de surveillance environnementales, qui sera mené parallèlement aux activités d'exploitation des hydrocarbures dans la mer de Beaufort, le programme permettant aux deux ministères responsables de s'acquitter de leurs responsabilités de réglementation. Le PSEMB était jugé nécessaire en raison a) des préoccupations d'ordre environnemental entraînées par les activités d'exploitation; 2) des incertitudes liées à l'évaluation des répercussions environnementales (ERE); 3) de la nécessité d'un plan de recherche et de surveillance qui soit pleinement intégré aux efforts actuels d'exploration et aux activités futures de production. Dans le rapport final du Comité d'examen environnemental de la mer de Beaufort (Bureau fédéral d'examen des évaluations environnementales, 1984), on a souligné la nécessité de mettre sur pied des programmes de recherche et de surveillance afin de faire face aux activités par étapes d'exploitation pétrolière et gazière dans la région. À cet égard, le Comité a félicité Affaires indiennes et du Nord Canada et Environnement Canada pour l'initiative qu'ils ont prise de parrainer le Projet de surveillance de l'environnement dans la mer de Beaufort.

En 1985, un programme semblable a été lancé afin de déterminer les priorités de recherche et de surveillance relativement aux répercussions possibles de l'exploitation et du transport des hydrocarbures dans les régions du delta et de la vallée du Mackenzie. Ce programme, qui est désigné sous le nom de Projet de surveillance de l'environnement du Mackenzie (PSEM), est mis en oeuvre selon des modalités analogues à celles du PSEMB et il est financé conjointement par Affaires indiennes et du Nord Canada, Environnement Canada, Pêches et Océans Canada et les gouvernements des Territoires du Nord-Ouest et du Yukon.

Le PSEM a été inactif en 1986. En 1987, on a jugé qu'il était important d'examiner les recherches pertinentes récentes afin de faire des recommandations sur les modifications à apporter aux hypothèses sous-jacentes au PSEM et de mettre à jour les plans pour les activités futures possibles d'exploitation des hydrocarbures dans la région visée par le projet. Le présent rapport décrit les activités du PSEM en 1987. On y fournit également suffisamment d'informations documentaires pour permettre aux lecteurs qui ne connaîtraient pas le PSEMB et le PSEM d'acquérir une compréhension générale de l'ensemble du programme.

CONTEXTE

Un bonne partie de la description ci-après du contexte du PSEM, depuis son lancement en 1985, provient directement du rapport final (AINC et allii, 1986). Nous n'avons pas toutefois jugé nécessaire ni souhaitable de le paraphraser ni de le reformuler. Cette description a été incluse afin que le lecteur puisse avoir une vue d'ensemble lui permettant d'établir le lien entre le PSEM II et le PSEM.

On a exprimé beaucoup d'inquiétude quant aux risques que représentent pour l'environnement les activités d'exploitation des hydrocarbures dans la mer de Beaufort et le delta et la vallée du Mackenzie. En raison de ces inquiétudes et des incertitudes liées à l'évaluation des répercussions environnementales, il était nécessaire de toute évidence de disposer de programmes de recherche et de surveillance environnementales qui soient pleinement intégrés aux plans actuels et futurs d'exploration et d'exploitation. Pour répondre à ce besoin, Affaires indiennes et du Nord Canada (AINC) et Environnement Canada ont lancé en 1983 le Projet de surveillance de l'environnement dans la mer de Beaufort (PSEMB). Si le PSEMB a permis d'orienter les activités de surveillance dans le milieu marin au large des côtes à partir de ce moment-là, il n'existait pas, par ailleurs, de programme semblable pour l'environnement terrestre et les eaux douces du delta et de la vallée du Mackenzie. Reconnaissant la nécessité d'un tel programme, AINC et Environnement Canada, en collaboration avec Pêches et Océans Canada et les gouvernements des Territoires du Nord-Ouest et du Yukon, ont mis sur pied au début de 1985 le Programme de surveillance de l'environnement du Mackenzie (PSEM).

L'objectif général de ce programme était de permettre de recommander des programmes de recherche et de surveillance qui :

1. traiteraient des répercussions importantes possibles;
2. seraient fondés sur la meilleure compréhension actuelle possible des scénarios de mise en valeur de l'industrie ainsi que des processus écologiques;
3. permettraient de répondre aux scénarios d'exploitation changeants de l'industrie et de réagir à l'information nouvelle sur les processus écologiques dans la région visée;
4. seraient pratiques et applicables;
5. comporteraient les éléments scientifiques et techniques qui en établissent le bien-fondé.

Le PSEM a été mis en oeuvre au moyen de techniques et de méthodes testées au cours du Programme de surveillance de l'environnement dans la mer de Beaufort (AINC et Environnement Canada, 1984 et 1985; AINC, 1986). Jusqu'à maintenant, dans le cadre du PSEM, on a tenu un premier atelier à Yellowknife (du 26 au 30 mars 1985); des réunions techniques sur l'exploitation de la faune, à Yellowknife (juin 1985), à Inuvik et à Norman Wells (septembre 1985); et un deuxième atelier, à Edmonton (du 4 au 8 novembre 1985). L'atelier de Yellowknife avait pour but d'obtenir les données de base permettant l'établissment de modèles conceptuels des répercussions de l'exploitation pétrolière et gazière sur la population et sur les ressources environnementales dans la région visée par l'étude. Ces modèles conceptuels constituent la base des hypothèses sur les répercussions et des recommandations sur le suivi de la recherche, dont on s'est servi tout au long du programme.

Nombre d'hypothèses élaborées avaient trait aux répercussions biophysiques des activités d'exploitation. Toutefois, le PSEM traite également des répercussions de l'exploitation pétrolière et gazière sur l'exploitation des poissons et de la faune. C'est pourquoi les habitants du Nord ont eu une influence considérable sur l'orientation adoptée pour le PSEM en ce qui a trait à l'exploitation de la faune et à l'élaboration des hypothèses sur les répercussions. Des réunions techniques spéciales sur cette exploitation ont été tenues dans les collectivités du Nord afin d'obtenir l'apport des Autochtones et de l'optimiser.

En se fondant sur les modèles conceptuels, on a élaboré un ensemble plus perfectionné d'hypothèses sur les répercussions. On a évalué ces hypothèses à l'atelier d'Edmonton et on a ensuite préparé des recommandations sur la surveillance et la recherche. Le rapport final (AINC et allii, 1986) expose ces recommandations dans le cadre des 25 hypothèses sur les répercussions.

Hypothèses de répercussions

L'élément central des méthodes utilisées pour le PSEM est le concept de l'hypothèse de répercussions. En termes simples, une hypothèse de répercussions est un ensemble d'énoncés reliant les activités d'exploitation à leurs répercussions possibles sur l'environnement. Chaque hypothèse comporte trois parties principales qui se définissent comme suit :

1. mesure visée - celle qui est la cause possible d'un effet quelconque;

2. élément évalué de l'écosystème (EEE) ou indicateur - qui permet de mesurer un effet;

3. liens - ensemble d'énoncés établissant le lien entre la mesure visée et l'EEE.

Surveillance

Pour les fins du projet, la surveillance consiste à tester chaque hypothèse de répercussions afin : a) de mesurer les répercussions environnementales; b) d'analyser les relations de cause à effet.

Dans ce contexte, la surveillance devient la mesure répétitive des variables qui sont susceptibles de changer par suite des répercussions directes ou indirectes des activités d'exploitation. Le principal but de la surveillance est de déterminer les causes des répercussions ne découlant pas de la variabilité naturelle. Les résultats obtenus peuvent être utilisés pour susciter une mesure d'atténuation au niveau réglementaire. La surveillance ne vise pas à assurer une supervision et elle ne fait pas partie du régime réglementaire utilisé pour faire en sorte que chaque société se conforme aux conditions de ses permis d'exploitation liées à l'environnement. La surveillance est plutôt définie ici comme un processus scientifique visant à vérifier des hypothèses sur les causes des répercussions environnementales et à voir comment elles s'expriment dans l'environnement.

Les types de programmes de surveillance ci-dessus, utilisés dans le cadre de la gestion de l'environnement, sont nécessaires en raison de notre capacité limitée de prédire les changements environnementaux que peuvent entraîner les activités d'exploitation. Les techniques d'évaluation sont limitées en raison de l'incertitude scientifique dans laquelle on se trouve pour ce qui est des relations de cause à effet entre les activités d'un projet et les ressources environnementales subissant des changements.

Évaluation et gestion de l'environnement axées sur l'adaptation

L'élaboration, le perfectionnement et l'évaluation des hypothèses de répercussions du PSEM, utilisées de concert avec la conception des études, ont été mis au point au moyen d'ateliers. Dans le cadre du PSEM, on a déterminé les répercussions et élaboré le plan de surveillance au moyen de la méthode des modèles conceptuels. Cette méthode, qui est fondée sur une évaluation et une gestion de l'environnement axées sur l'adaptation (Holling, 1978), a été utilisée pour la première fois au cours du PSEMB (AINC et Environnement Canada, 1984 et 1985, et Everitt et allii, 1985). L'approche de base comporte huit tâches et est décrite dans le document d'AINC et allii (1986 : 4) :

1. détermination des éléments évalués de l'écosystème (EEE);
2. définition des activités d'exploitation;
3. établissement d'un échéancier et exécution de celui-ci au cours de l'année;
4. détermination de la superficie visée et exécution;
5. détermination des hypothèses de répercussions servant à établir le lien causal entre les activités d'exploitation et les EEE;
6. examen des hypothèses de répercussions pour en vérifier la validité, la pertinence et la crédibilité;
7. évaluation des hypothèses de répercussions;
8. conception des programmes de recherche et de surveillance.

L'exécution de chacune de ces tâches comporte l'élaboration de modèles conceptuels, la tenue d'ateliers ou la production de rapports. Les cinq premières tâches nécessaires à l'élaboration du modèle conceptuel sont réalisées dans le cadre d'un atelier d'établissement des modèles. La meilleure façon d'exécuter les trois autres tâches est de travailler en petits groupes, qui peuvent ou non être intégrés à un atelier plus important. On trouve une description détaillée des tâches dans le document d'Everitt et allii (1985) et dans celui d'AINC et d'Environnement Canada (1985).

Le processus de définition des problèmes pour le programme du PSEM est décrit en détail dans le document d'AINC et allii (1986). En bref, ce processus renferme : 1) la définition des secteurs visés par l'étude; 2) la détermination des activités d'exploitation proposées; 3) la définition des éléments évalués de l'écosystème. Beanlands et Duinker (1983) définissent les éléments évalués de l'écosystèmes (EEE) comme :

> "les caractéristiques ou les éléments de l'environnement qui suscitent les préoccupations du public ou des spécialistes, ou des deux, et sur lesquels il convient de faire porter principalement les activités d'évaluation... ces éléments peuvent être déterminés en se fondant sur les préoccupations

du public à l'égard des valeurs sociales, culturelles, économiques et esthétiques. Ils peuvent aussi refléter les préoccupations scientifiques de la communauté des spécialistes..."

Cette définition est extrêmement générale et chaque fois qu'on l'applique, on doit la reprendre de façon plus précise. Dans le cadre du PSEM, les EEE ont été définis comme des activités, des ressources ou des caractéristiques de l'environnement qui :

1. sont importantes pour les populations locales; ou

2. revêtent un intérêt national ou international; et

3. si elles subissent des modifications par rapport à leur état actuel, elles seront importantes pour évaluer les répercussions des activités d'exploitation et pour orienter les politiques de réglementation.

On trouvera dans le document d'AINC et allii (1986 : 6-10) les listes des éléments évalués des écosystèmes et des activités d'exploitation proposées dans le cadre du programme du PSEM ainsi que l'indication de l'ensemble de la région visée par l'étude et des emplacements particuliers faisant l'objet d'études.

ACTIVITÉS EN 1987

Depuis le lancement du PSEM, on a réalisé tout un éventail d'activités de recherche dans la région visée par l'étude. Certaines de ces recherches sont orientées en fonction des hypothèses élaborées en vertu du PSEM et d'autres recherches (à savoir, certaines liées au Programme de surveillance de l'environnement de Norman Wells) ont été entreprises avant le lancement du PSEM. Un atelier a été tenu à Yellowknife à la fin de novembre 1987 pour évaluer les résultats du programme de Norman Wells et pour aider à déterminer les priorités futures.

Les principaux objectifs de la deuxième étape du PSEM consistaient à rassembler en un seul document toutes les données de recherche et de contrôle liées aux 25 hypothèses de répercussions établies au cours de la première année du projet. Ce condensé d'informations sera utilisé pour planifier les activités futures du PSEM et pourra constituer un document de référence fort utile pour l'élaboration et l'examen des demandes prévues relativement à la construction de pipelines et aux activités de production d'hydrocarbures dans les régions de la vallée et du delta du Mackenzie (T. N.-O.).

Les objectifs secondaires consistaient à : 1) indiquer les secteurs où il y aurait peut-être lieu de réviser les hypothèses actuelles de répercussions ou d'établir de nouvelles hypothèse; 2) fournir un scénario à jour des activités d'exploitation des hydrocarbures.

Méthodes

Pour la détermination, l'examen et la compilation de tous les renseignements pertinents, on a procédé selon une méthode systématique qui comportait les étapes suivantes :

1. On a effectué des recherches dans des bibliothèques privées et des bibliothèques de sociétés. La plupart des membres de l'équipe du projet, ou leur société, disposent en effet de bibliothèques bien garnies et à jour de documents traitant de leur domaine de spécialisation. Plusieurs rapports et documents utiles dont on s'est servi étaient déjà entre les mains des intéressés et certaines des études pertinentes examinées avaient même été élaborées par des membres de l'équipe de l'étude.

2. On a aussi fait des entrevues téléphoniques pour trouver d'autres sources de données et d'autres rapports.

3. Toutes les études pertinentes et les informations connexes ont été examinées, compilées et résumées.

4. On a décrit les programmes de recherche incomplets ou en cours, mais on n'a pas essayé de présenter de données ou de tirer de conclusions de ces programmes.

5. On a décrit brièvement les recherches prévues seulement s'il existait des fonds pour ces études et si les organismes ou les organisations responsables avaient été déterminés.

Tableau 3. Modifications recommandées aux hypothèses biophysiques existantes du PSEM (1 à 17) et nouvelles hypothèses nécessaires

Hypothèse numéro	Nombre de liens	Objet de l'hypothèse	Modification de l'hypothèse	Nouvelle hypothèse
1	10	Déchets, habitat et renards	Non	Non
2	10	Circulation et caribous	Oui	Non
3	7	Déchets, habitat et ours bruns	Non	Non
4	12	Niveaux d'eau et rats musqués	Oui	Non
5	8	Modifications à l'habitat et orignaux	Oui	Non
6	10	Modifications à l'habitat et martres	Non	Non
7	13	Perturbations et faune aquatique	Non	Non
8	9	Perturbations et rapaces	Non	Non
9	3	Prédateurs et faune aquatique	Non	Non
10	4	Pétrole et faune aquatique	Non	Non
11	8	Affaissements de terrain, niveaux d'eau, poissons et faune	Non ?	Non
12	1	Émissions d'éléments polluants et qualité de l'air	Non	Non
13	2	Perturbations et qualité des poissons	Non	Non
14	4	Accès amélioré et poissons	Oui	Non
15A, B	5, 13	Effluents, qualité de l'eau et poissons	Non	Non
16	16	Corridors linéaires et efficacité de la pêche	Non	Non
17	1	Déchets et carcajous	Non	Non

RECOMMANDATIONS POUR DE NOUVELLES HYPOTHÈSES OU DES MODIFICATIONS AUX HYPOTHÈSES ACTUELLES ET AUX PROGRAMMES DE SURVEILLANCE

Le tableau 3 et le texte d'accompagnement résument les recommandations sur les modifications susceptibles d'êtres apportées aux hypothèses biophysiques actuelles et les hypothèses nouvelles dont on pourrait avoir besoin. Les recommandations se fondent sur l'examen des documents existants et les résultats de recherches et sur le fruit des discussions avec des chercheurs oeuvrant dans le secteur étudié du PSEM. Les tableaux 4, 5 et 6 ainsi que les textes d'accompagnement résument les recommandations sur les modifications susceptibles d'être apportées aux hypothèses actuelles sur l'exploitation de la faune et aux programmes de surveillance de cette exploitation.

On fournit une brève justification pour chacune des modifications ou révisions proposées. Toutefois, le travail effectif de modification des hypothèses ou d'élaboration de nouvelles hypothèses ou de nouveaux programmes de surveillance n'entre pas dans le cadre de cette étape du PSEM. La meilleure façon d'apporter ces modifications serait d'utiliser un processus plus efficient et mieux structuré prévoyant la participation d'un effectif plus important.

Hypothèses biophysiques 1 à 17

Hypothèse 2 : Circulation et caribous

L'examen des documents récents concernant les répercussions des routes et de la circulation sur les caribous et la répartition saisonnière de la harde de la Porcupine, relativement aux routes proposées pour le Versant nord, révèle qu'il sera peut-être nécessaire d'apporter des modifications importantes à l'hypothèse 2.

Les liens 4 (l'accès réduit aux habitats ne comportant pas d'insectes augmentera l'incidence des parasites et réduira la qualité des peaux de caribous) et 5 (la diminution du gras chez les bêtes entraînera une baisse de la qualité de la viande et des peaux de caribous) ont un caractère spéculatif et se fondent sur plusieurs hypothèses contestables. La qualité de la viande et des peaux dépendent d'une variété de facteurs environnementaux et physiologiques dont la plupart semblent ne pas dépendre des répercussions possibles des routes ou de la circulation. Il faudrait réévaluer la relation entre la circulation et la dynamique énergétique du caribou, ainsi que le lien, plus faible, entre la dynamique énergétique et la qualité de la viande ou des peaux en se fondant sur des renseignements plus récents (par exemple, les aperçus de projets 2 à 19).

Il faudrait évaluer s'il y a lieu d'établir un lien nouveau pour ce qui est des répercussions de la chasse légale et illégale pratiquée à partir des routes d'accès existantes et nouvelles, car on sait que celles-ci ont une incidence importante sur d'autres hardes de caribous d'Amérique du Nord. On pourrait considérer ce lien comme une omission importante dans la présentation initiale de l'hypothèse 2.

Hypothèse 4 : Niveaux d'eau et rats musqués

Les informations publiées laissent entendre qu'il faudrait ajouter un lien supplémentaire (lien 7A) pour rendre compte du nombre accru des cas de prédations du rat musqué par le vison lorsque le niveau de l'eau est bas. Toutefois, les conclusions du groupe de travail du PSEM de 1986 indiquaient que les niveaux d'eau dans le secteur visé par l'étude, où la densité des rats musqués est élevée, ne seraient pas modifiés de façon importante par les activités d'exploitation. Toutefois, l'hypothèse dans son ensemble ne semble pas valide et les modifications mineures indiquées seraient insuffisantes pour justifier l'hypothèse.

Hypothèse 5 : Changements dans l'habitat et orignaux

Il semblerait utile d'apporter plusieurs modifications à cette hypothèse, qui est fondée sur des études récentes. Il existe également certains énoncés contradictoires concernant la validité des liens exposés dans le rapport du PSEM de 1986. La qualité de la nourriture revêt vraisemblablement une plus grande importance que sa quantité. Il faudrait que ce facteur se reflète dans le lien 1 (le fait de défricher accroîtra la quantité de nourriture disponible pour les orignaux). Le lien 1 doit aussi faire l'objet d'une précision, afin d'inclure les secteurs recouverts surtout de forêt. On a constaté que les opérations sismiques réalisées dans les régions de toundra ont des répercussions négatives sur l'ensemble de la végétation existant le long des tracés de sondages sismiques.

Le lien 5 (les pipelines installés au-dessus du niveau du sol modifieront les voies de migration des orignaux) suppose que ces pipelines empêcheront le passage de ces animaux et entraîneront des changements dans leurs mouvements migratoires. Des renseignements récents révèlent que les orignaux qui sont suffisamment motivés pour passer par-dessus un pipeline (par exemple, au cours de leurs migrations) franchiront effectivement un tel obstacle, quelles que soient les caractéristiques du pipeline. C'est pourquoi les liens 5, 6 (l'équilibre énergétique détermine les capacités de reproduction des orignaux adultes) et 7 (les capacités de reproduction déterminent l'importance de la population d'orignaux) ont besoin d'être modifiés pour refléter le faible risque que les pipelines situés au-dessus du sol posent pour les voies migratoires des orignaux.

Hypothèse 11 : Affaissements de terrain

On a constaté à l'évidence une très grande incertitude dans les discussions du groupe de travail qui examinait officiellement les répercussions des affaissements indirects de terrains sur les poissons, la faune aquatique et les rats musqués. Comme on l'a mentionné dans le document d'AINC et allii (1986), il n'existe pas actuellement de méthode fiable pour prédire avec exactitude la compaction des réservoirs et l'affaissement conséquent de terrains. Ce facteur, joint à l'incertitude quant aux affaissements entraînés indirectement par des changements dans le pergélisol et la glace contenue dans le sol, fait que les conclusions tirées sont très relatives. Pour ces raisons, il peut s'avérer avantageux de réexaminer la question des affaissements de terrain entraînés par diverses causes, à des intervalles périodiques.

Hypothèse 14 : Accès amélioré et meilleure exploitation des poissons

Dans le cadre de l'hypothèse 14, on examine seulement, pour le moment, les répercussions de l'exploitation sur la répartition des poissons et sur leur abondance. Il faudrait penser à modifier l'hypothèse en se penchant également sur les répercussions de l'exploitation des poissons sur la qualité de ceux-ci. De façon caractéristique, les activités initiales d'exploitation de cette ressource se concentrent sur les sujets les plus gros pouvant être capturés. Il en est ainsi tant pour la pêche sportive que pour la pêche commerciale ou de subsistance. C'est pourquoi, progressivement, les poissons qu'on attrape par la suite dans les activités de pêche sont plus petits. Ainsi, la taille moyenne des poissons dans les populations faisant l'objet d'une pêche intensive pourra diminuer de façon importante. Cette situation peut en retour modifier les modalités actuelles (et futures) de la pêche. Il faut aussi considérer cette répercussion dans l'hypothèse 23, qui traite de l'exploitation de la faune.

Hypothèses sur l'exploitation de la faune 18 à 25

Contexte

Avant d'élaborer des hypothèses soutenables sur l'exploitation de la faune, il fallait établir un modèle des répercussions des activités d'exploitation de l'industrie sur ce type d'exploitation auquel s'adonnent les Autochtones (AINC et allii : 281-231). Les principaux éléments de ce modèle, tels qu'ils s'appliquent aux hypothèses 18 à 25, étaient les suivants :

1. emplois salariés;
2. activités visées;
3. exploitation de la faune;
4. entraide mutuelle ou partage, ou les deux;
5. accès;
6. concurrence entre les exploitants de la faune;
7. base de ressources (répartition et abondance des mammifères, des oiseaux et des poissons);
8. conflit entre les activités industrielles et les activités d'exploitation de la faune;
9. indemnisation.

On a recommandé la vérification de chacun des éléments pour l'une ou plusieurs des hypothèses initiales (tableau 4).

Les Autochtones des collectivités de la vallée du Mackenzie, de la région de Great Bear, du delta du Mackenzie et du littoral de la mer de Beaufort ont exercé une grande influence sur les aspects du PSEM concernant l'exploitation de la faune et sur l'élaboration des hypothèses de répercussions. Tout au long du projet, les participants autochtones ont insisté sur deux points : 1) les collectivités souhaitent apporter leur participation à la surveillance; 2) elles considèrent que l'exploitation de la faune est particulière à chacune des différentes espèces et orientée en fonction des besoins de chaque collectivité. Pris globalement, ces facteurs militent en faveur de programmes de contrôle prévoyant la participation des collectivités et axés sur l'importance des différentes populations animales. La combinaison de ce besoin sociologique à des programmes de surveillance scientifiquement applicables constitue un objectif important de la partie du PSEM concernant l'exploitation de la faune.

Aperçus des résumés de projets

Afin de disposer de données de base pour l'évaluation des aperçus de projets concernant les hypothèses sur l'exploitation de la faune, dans le cadre du PSEM, on a examiné chacun des projets pour déterminer lesquels des principaux éléments (énumérés plus tôt) de l'hypothèse sur l'exploitation des ressources fauniques étaient traités. En outre, on a évalué les projets de façon à déterminer s'ils étaient : 1) réalisés dans la collectivité; 2) si les contrôles étaient fondés sur l'abondance des populations animales au niveau local.

Une brève analyse (tableau 5) d'environ 30 résumés de projets a montré que les activités les plus récentes de surveillance et de recherche semblent s'être concentrées sur les éléments de l'exploitation de la faune (8 sur 20) et sur ceux des emplois salariés (5 sur 20). La plupart des autres éléments ont été quelque peu négligés. Les activités visées (à titre d'élément) ont été prises en considération dans 4 des 20 projets, mais l'accent a été mis principalement sur l'objet des activités dans 3 des 20 études; chacune de ces trois études portait sur la Nation dénée ou la collectivité de Fort Good Hope, ou les deux. On ne semble pas avoir rapporté les résultats de la surveillance exercée sur l'abondance des ressources fauniques au niveau local. Vu l'importance de ce type de surveillance, il est nécessaire de faire porter les travaux futurs sur ce secteur.

Modifications aux programmes de surveillance

Si l'on considère l'évolution du PSEM, l'élaboration des hypothèses sur l'exploitation de la faune laissait à désirer comparativement à l'établissement des hypothèses biophysiques. En conséquence, les recommandations finales issues des activités de surveillance, en ce qui a trait aux hypothèses sur l'exploitation de la faune, ont été moins bien définies si on les compare à celles portant sur les hypothèses biophysiques. Par exemple, les recommandations concernant les activités de surveillance liées aux hypothèses 22 à 25 étaient faites en général pour fournir des directives détaillées à l'intention des projets de surveillance futurs. En outre, de nombreuses études de surveillance initiales ont été conçues et réalisées indépendamment les unes des autres et ont porté par conséquent sur des objectifs différents. C'est pourquoi nous recommandons de modifier quelque peu ces hypothèses (tableau 6) afin de rendre compte plus fidèlement des préoccupations particulières aux collectivités et reliées aux différentes espèces animales.

Modifications aux hypothèses

L'équipe de la présente étude n'a pu arriver à une conclusion unanime en ce qui a trait à la nécessité de modifier l'hypothèse 22 (répercussions des emplois salariés sur l'exploitation de la faune). Une opinion voulait que cette hypothèse soit modifiée et précisée davantage. Par ailleurs, une opinion contraire voulait que certaines des conclusions exprimées dans les études récentes soient provisoires ou d'ordre spéculatif ou que ces données se prêtent à différentes interprétations, de sorte qu'il n'y avait pas lieu de modifier l'hypothèse. Cette différence d'opinion démontre clairement la nécessité d'un examen critique de tous les liens de l'hypothèse 22 et d'une réévaluation des conclusions; on a recommandé en outre des programmes de recherche et de surveillance. Les projets tel que ceux examinés dans les aperçus des projets 18-6, 18-7, 22-1, 22-2 et 22-3 conviennent particulièrement à l'hypothèse 22.

Non-concordance des hypothèses biophysiques et des hypothèses sur l'exploitation des ressources fauniques

Un examen attentif des hypothèses biophysiques (1 à 17) révèle qu'elles sont pour la plupart reliées aux espèces et qu'elles traitent de répercussions régionales. Toutefois, les hypothèses sur l'exploitation des ressources fauniques (18 à 25), sauf celles concernant les baleines blanches, ne sont pas reliées aux espèces et sont axées davantage sur les répercussions sur les collectivités. De même, la plupart des hypothèses concernant les poissons et la faune semblent être liées davantage aux répercussions générales sur la faune pour ce qui est du niveau des populations, plutôt qu'aux répercussions sur les collectivités locales, même si les répercussions au niveau local constituent une préoccupation importante pour les collectivités. Ce manque de concordance entre les deux types d'hypothèses semble indiquer qu'il convient d'adopter un point de vue différent si on veut progresser au niveau de la surveillance de l'exploitation de la faune. Pour comprendre les répercussions de l'exploitation pétrolière et gazière sur l'exploitation de la faune, nous devons surveiller ces activités ainsi que les changements dans la répartition et l'abondance des différentes espèces et des populations locales d'animaux près des collectivités.

Tableau 4. Résumé des 9 principaux éléments traités dans chacune des hypothèses sur l'exploitation de la faune (x). Les éléments pour lesquels une surveillance a été recommandée à l'origine sont indiqués par un "o".

Éléments	Hypothèses							
	18	19	20	21	22	23	24	25
Emplois salariés	o				o			
Activités visées	x	x	x		o	o	o	
Exploitation de la faune	o	o	x	x	o	o	o	o
Entraide/partage					o			
Accès				x		o		
Concurrence			x			o		o
Base de ressources	o			x	x		x	o
Conflits							o	
Indemnisation							o	

Tableau 5. Nombre d'aperçus (projets) traitant de chacun des 9 éléments principaux des hypothèses sur l'exploitation de la faune. Deux éléments importants ont été ajoutés (*).

Élément	Nombre d'études
Emplois salariés	5
Activités visées	4
Exploitation de la faune	8
Entraide/partage	0
Accès	1
Concurrence	2
Base de ressources	0
Conflits	3
Indemnisation	2
Participation de la collectivité*	3
Abondance au niveau local*	0

Tableau 6. Modifications recommandées aux hypothèses 18 à 25 et programmes connexes de surveillance.

Numéro de l'hypothèse	Nombre de liens	Sujet de l'hypothèse	Modification de l'hypothèse	Modification de la surveillance
18	10	Emplois salariés et exploitation de la baleine blanche	Non	Non
19	2	Navires et baleines blanches	Non	Non
20	5	Accroissement de la chasse et baleines blanches	Non	Non
21	3	Accès accru et baleines blanches	Non	Non
22	8	Emplois salariés et accroissement de la chasse	Peut-être	Oui
23	10	Accès accru et exploitation de la faune	Non	Oui
24	6	Conflits dans l'utilisation des terres et exploitation de la faune	Non	Oui
25	7	Conflits dans l'exploitation de la faune - exploitation non locale par opposition à l'exploitation locale	Non	Oui

INTRODUCTION

During 1983, Indian and Northern Affairs Canada and Environment Canada initiated the Beaufort Environmental Monitoring Project (BEMP). The program is to provide the technical basis for the design, operation and evaluation of a comprehensive and defensible environmental research and monitoring program to accompany hydrocarbon development in the Beaufort Sea relative to the regulatory responsibilities of the sponsoring departments. BEMP was considered necessary because of: 1) environmental concerns regarding this development; 2) uncertainties associated with Environmental Impact Assessment (EIA); and 3) the need for a research and monitoring plan that is fully integrated with ongoing exploration and future production activities. In the Final Report of the Beaufort Sea Environmental Assessment Panel (FEARO 1984), the need for research and monitoring programs to accompany phased oil and gas development in the region was emphasized. In this regard, the Panel commended Indian and Northern Affairs Canada and Environment Canada on their initiative in sponsoring the Beaufort Environmental Monitoring Project.

In 1985, a comparable program was initiated to determine research and monitoring priorities related to possible effects of hydrocarbon development and transportation in the Mackenzie Delta and Valley regions. This program is referred to as the Mackenzie Environmental Monitoring Project (MEMP), is following procedures similar to those employed in BEMP, and is jointly funded by Indian and Northern Affairs Canada, Environment Canada, Fisheries and Oceans Canada, and the Governments of the Northwest Territories and Yukon.

MEMP was inactive in 1986. In 1987 it was considered important to review recent relevant research, to comment on the need for revision of MEMP hypotheses and to provide an update of possible future hydrocarbon development plans for the MEMP study area. This report describes 1987 MEMP activities. Sufficient background is provided with the report so that readers, who may be unfamiliar with either BEMP or MEMP, can obtain an overall understanding of the entire program.

BACKGROUND

Much of the following description of the background of MEMP since its inception in 1985 has been taken directly from the final report (INAC et al. 1986). We have not considered it desirable or necessary to paraphrase or reword it. We have included it to provide the perspective necessary to assess how MEMP II relates to MEMP.

There has been considerable concern that hydrocarbon development activities in the Beaufort Sea, Mackenzie Delta, and Mackenzie Valley may result in adverse environmental impacts. Because of these concerns and the recognized uncertainties associated with environmental impact assessment, there was a clear need for environmental research and monitoring programs that were fully integrated with ongoing and future exploration and development plans. In response to this need, Indian and Northern Affairs Canada (INAC) and Environment Canada initiated the Beaufort Environmental Monitoring Project (BEMP) in 1983. While BEMP has guided monitoring in the offshore marine environment since that time, no comparable program existed in the terrestrial and freshwater environment for the Mackenzie Delta and the Mackenzie Valley. In recognition of the need for such a program, INAC and Environment Canada, together with the Department of Fisheries and Oceans, the Government of the Northwest Territories, and the Yukon Territorial Government, initiated the Mackenzie Environmental Monitoring Program (MEMP) in early 1985.

The overall objective of the Mackenzie Environmental Monitoring Program has been to recommend monitoring and research programs that would:

1. address significant potential impacts;
2. be based on the best current understanding of industrial development scenarios and ecological processes;
3. have the capability to respond to changing industrial development scenarios and new information regarding ecological processes in the region;
4. be applicable and practical; and
5. be supported with a full scientific and technical justification.

MEMP has been conducted using techniques and procedures proven during the Beaufort Environmental Monitoring Program (INAC and Environment Canada 1984, 1985; INAC 1986). To date, MEMP has proceeded through an initial workshop in Yellowknife (26-30 March 1985); technical meetings on resource harvesting held in Yellowknife (June 1985), and Inuvik and Norman Wells (September 1985); and a second workshop in Edmonton (4-8 November 1985). The Yellowknife workshop was designed to obtain the raw material that would allow the construction of conceptual models of effects of oil and gas development on the people and the environmental resources in the study area. These conceptual models form the basis of the impact hypotheses and research monitoring recommendations that have been used throughout the program.

Many of the hypotheses developed were concerned with the biophysical effects of development. However, MEMP is also concerned with the effects of oil and gas development on the harvesting of fish and wildlife. This means that northern residents have had considerable influence over the direction taken by MEMP with respect to resource harvesting and the development of impact hypotheses. Special technical meetings on resource harvesting were held in northern communities to obtain and maximize the contribution of native people.

Based on the conceptual models, a refined set of impact hypotheses was developed. These hypotheses were evaluated at the Edmonton workshop and recommendations for monitoring and research were prepared. The final report (INAC et al. 1986) presents those recommendations within the framework of 25 impact hypotheses.

Impact Hypotheses

Central to the methods of MEMP is the concept of an impact hypothesis. Simply stated, an impact hypothesis is a set of statements that link development activities with their potential environmental effects. Every impact hypothesis has three primary parts that must be defined:

1. the action - that which is the potential cause of an effect;
2. the valued ecosystem component (VEC) or indicator - that which is the measure of an effect; and
3. the linkages - that set of statements that link the action to the VEC.

Monitoring

For purposes of this project, monitoring is a test of an impact hypothesis designed to: a) measure environmental impacts; and b) analyse cause-effect relationships.

Monitoring in this context becomes the repetitive measurement of variables that are likely to change due to direct or indirect effects of development activity. The primary purpose of monitoring is to determine the causes of effects not associated with natural variability. The results of monitoring can be used to trigger a mitigative regulatory response. Monitoring is not surveillance, nor is it part of the regulatory process used to ensure that an industry meets the environmental terms and conditions of its operating permits. Rather, monitoring is defined here as a scientific process designed to test specific hypotheses on the causes of environmental impacts and how they are expressed in the environment.

The above types of monitoring programs in environmental management are needed because of our limited capability to predict environmental change as a consequence of development. Assessment techniques are limited because of scientific uncertainty about the cause and effect relationships between project activities and the environmental resources being changed.

Adaptive Environmental Assessment and Management

The development, refinement and evaluation of MEMP impact hypotheses combined with the design of specific studies were organized through the use of workshops. In MEMP the identification of impacts and development of a monitoring plan were organized through the use of a conceptual modeling approach. This approach is based on Adaptive Environmental Assessment and Management (Holling 1978) and was first used in BEMP (INAC and Environment Canada 1984, 1985, and Everitt et al. 1985). The basic approach involves eight tasks, and is described in INAC et al. (1986:4):

1. identification of valued ecosystem components (VECs);
2. identification of development activities;
3. identification of temporal horizon and within-year resolution;
4. identification of the spatial extent and resolution;
5. identification of impact hypotheses that causally relate development activities to VECs;

6. screening of impact hypotheses for validity, relevance and credibility;

7. evaluation of impact hypotheses; and

8. design of research and monitoring programs.

Execution of each of these tasks involves conceptual modeling, workshops or reporting. The first five tasks necessary for the development of the conceptual model are accomplished efficiently in a modeling workshop. The remaining tasks are best accomplished in small groups that may or may not be part of a larger workshop. A detailed description of the tasks is provided in Everitt et al. (1985) and INAC and Environment Canada (1985).

The process of problem definition for the MEMP program is described in detail in INAC et al. (1986). Briefly, this process includes: (1) the definition of study areas; (2) determination of proposed development activities; and (3) determination of valued ecosystem components. Beanlands and Duinker (1983) define valued ecosystem components (VECs) as:

> "attributes or components of the environment for which there is public or professional concern, or both, and to which the assessment should be primarily directed . . . these may be determined on the basis of perceived public concerns related to social, cultural, economic, and aesthetic values. They may also reflect the scientific concerns of the professional community . . . "

This definition is extremely general and each new application must make a more specific definition. In MEMP, VECs have been defined as activities, resources or environmental features that:

1. are important to local human populations; or

2. have national or international profiles; and

3. if altered from their existing status, will be important in evaluating the impacts of development and in focusing regulatory policy.

The lists of valued ecosystem components and of proposed development activities for the MEMP program, as well as the overall study area and specific study sites are given in INAC et al. (1986:6-10).

ACTIVITIES IN 1987

Since the inception of MEMP, a variety of research has been conducted in the study area. Some of this research has been guided by the MEMP hypotheses and other research (i.e., some associated with the Norman Wells Environmental Monitoring Program) was initiated prior to the inception of MEMP. A workshop was held in Yellowknife in late November 1987 to assess the results of the Norman Wells program and to help determine future priorities.

The primary objective of Phase II of MEMP was to assemble in a single document all the relevant research and monitoring information related to the

25 impact hypotheses identified in the first year of the project. This compendium of information will be used to plan future activities of the Mackenzie Environmental Monitoring Project and will serve as a useful reference document for the preparation and review of the expected pipeline and hydrocarbon production applications for the Mackenzie Valley and Mackenzie Delta areas of the NWT.

Secondary objectives were to: 1) indicate possible areas for revision of existing impact hypotheses or the need for new hypotheses; and 2) provide an updated hydrocarbon development scenario.

Methods

A systematic approach was followed in the identification, reviewing and compilation of all relevant information. This included the following steps:

1. Personal and company libraries were searched. Most members of the project team, or their companies, maintain extensive, up-to-date libraries of current literature in their fields of expertise. Many of the relevant reports and papers were in-hand and some of the pertinent studies reviewed have, in fact, been performed by members of the study team.

2. Telephone interviews were used to identify additional sources of data and reports.

3. All relevant studies and associated information were reviewed, compiled and summarized.

4. Incomplete or ongoing research programs have been described but no attempt has been made to present data or to draw conclusions from such programs.

5. Planned research has been briefly described only if funding for studies is in place and responsible agencies or organizations are identified.

Report Organization

The following report is divided into three parts. The first gives current views on possible hydrocarbon development in the MEMP study area (Fig. 1). PART II describes recent research in relation to each hypothesis and PART III contains suggested revisions to hypotheses and preliminary recommendations for new hypotheses.

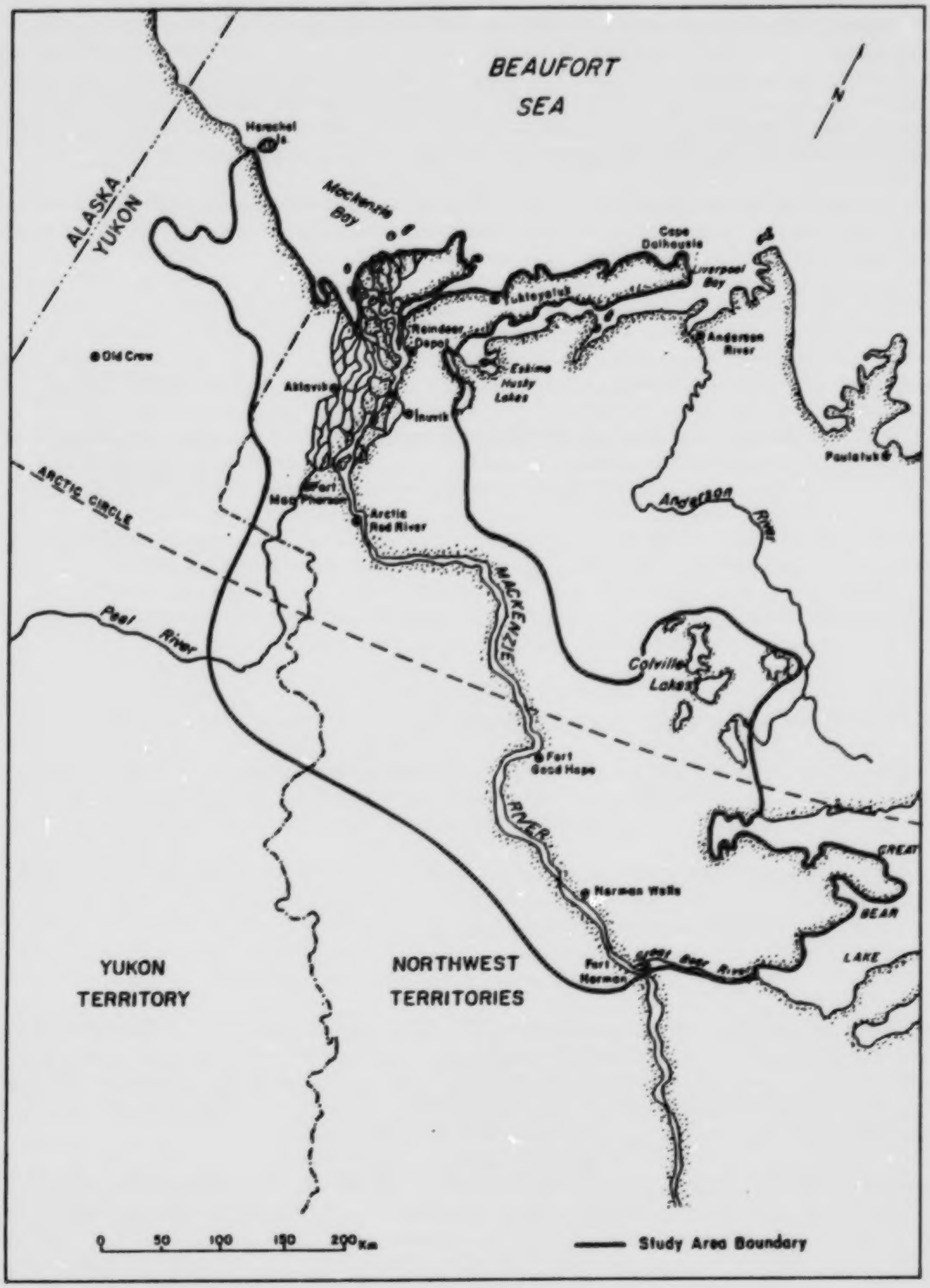

BEAUFORT SEA
N
Herschel Is
Mackenzie Bay
ALASKA
YUKON
Cape Dalhousie
Liverpool Bay
Tuktoyaktuk
Reindeer Depot
Anderson River
Eskimo Husky Lakes
Old Crow
Aklavik
Inuvik
Paulatuk
ARCTIC CIRCLE
Fort McPherson
Arctic Red River
Anderson River
MACKENZIE RIVER
Peel River
Colville Lakes
Fort Good Hope
GREAT BEAR LAKE
Norman Wells
Fort Norman
Great Bear River
YUKON TERRITORY
NORTHWEST TERRITORIES
0 50 100 150 200 Km
Study Area Boundary

Figure 1. Boundaries of the MEMP study area.

PART I:

AN UPDATED HYDROCARBON DEVELOPMENT SCENARIO FOR THE MEMP STUDY AREA

INTRODUCTION

A scenario of possible future hydrocarbon development activities in the MEMP study area was presented as Appendix A (R.A. Owens Environmental Services Ltd. 1985) in the 1985-86 final report for this project (INAC et al. 1986). At that time, development was occurring in the Mackenzie Delta, Colville Lake and Norman Wells areas, as well as outside the MEMP study area in part of the southeast Beaufort Sea. However, Owens (1985) emphasized that future hydrocarbon development in the region would depend largely on the type and timing of transport systems put in place. The most probable scenario was considered to be construction of two transport systems - the Polar Gas pipeline (1987-1991) to Edson, Alberta and a mid-sized oil pipeline (1992-1996) to Zama Lake, Alberta. This assumed additional hydrocarbon discoveries in the Mackenzie Delta and Colville Lake regions but not near Norman Wells.

This section briefly reviews current activities of the oil and gas industry in the region and discusses the options and projections for future development of hydrocarbon reserves. It is emphasized from the outset that most of the scenario presented in Owens (1985) remains valid except for the construction timing of specific transport systems. Accordingly, readers are referred to the previous MEMP report for a detailed discussion of various pipeline proposals for the Mackenzie Delta and Valley region, as well as a history of hydrocarbon exploration activities in the MEMP study area.

Information presented below was obtained during informal discussions with knowledgeable industry representatives

RECENT ACTIVITIES OF THE OIL AND GAS INDUSTRY

During the last three years, there has been a reduction in the level of exploration activity by the petroleum industry compared to the late 1970s and early 1980s. Some of the recent activities of the industry have included:

1. Completion of the Interprovincial Pipeline (IPL) from Norman Wells to Zama to support increased oil production from ESSO's Norman Wells field;

2. Continued seismic exploration by ESSO in the Mackenzie Delta, particularly in the vicinity of the Taglu gas field;

3. Offshore drilling by ESSO at Minuk I-53 (sacrificial beach artificial island) and Kaubvik I-43 (caisson on berm);

4. Further delineation drilling (I-65 and F-24) and an Extended Flow Test (EFT) by Gulf at Amauligak, including removal of 50,400 m^3 of crude oil and transport of this oil to Japan in the MV Gulf Beaufort;

5. Submission of an application by Gulf for an Extended Production Testing Project for Amauligak that would involve a

production rate of 3200-5600 m^3 per day for 100 to 125 days per year (July-October) and shipment of oil out of the Beaufort Sea by shuttle tanker on an average of about once a week; and

6. Exploratory drilling by Chevron near Fort Good Hope and by Conoco near Fort Norman.

FUTURE DEVELOPMENT SCENARIO

Exploration and Production Drilling

At present, ESSO expects to focus its activities on the development of natural gas reserves in the Mackenzie Delta and perhaps in adjacent shallow-water leases in the Beaufort Sea. Further exploratory drilling is not expected to occur in the Colville Lake region, although production from the Norman Wells oil field will continue for the foreseeable future.

As in the past two years, Dome Petroleum does not anticipate any offshore exploration activity in 1988. However, renewed drilling activity may occur at Adlartok in the following year, depending on the specific interests of Amoco in development of Dome's Beaufort oil reserves.

Gulf Canada is expected to focus its efforts on the development of the Amauligak field over the next few years. Depending on the results of further delineation drilling being completed this winter at the F-24 well site, future activities could include an Extended Production Flow Test (EPFT) involving seasonal transport of oil out of the region to the west in shuttle tanker(s). There is considerable optimism that the Amauligak field will support long-term production and may justify construction of a mid-sized oil pipeline down the Mackenzie Valley. However, other than this pipeline and support requirements described below, the EPFT and other offshore activities of Gulf would occur outside the MEMP study area.

Other operators such as Conoco and Chevron will also likely continue exploratory drilling within the MEMP study area in the next few years, particularly if oil and/or gas reserves sufficient to justify construction of pipelines are confirmed by ESSO, Gulf and Dome.

In the scenario presented in Owens (1985), it was assumed that several new oil and gas fields would be discovered during ongoing exploration programs. The location and number of these additional fields is shown in Table 1. Of these new discoveries, five fields (2 offshore gas, 2 offshore oil and 1 onshore oil) were assumed to be identified by 1989. It appears unlikely that this assumption will be realized and, therefore, the projected schedule for construction of transport systems will almost certainly be delayed to the early 1990s rather than late 1980s as suggested in Owens (1985).

Earlier assumptions regarding the most probable oil and gas fields to be developed first are still considered valid. Owens (1985) suggested that initial gas production from the Delta would be from onshore reserves at Taglu, Niglintgak and Parsons Lake, whereas both offshore (e.g., Amauligak, Tarsuit, Nipterk and onshore (e.g., Adgo, Atkinson, Tuktoyaktuk, Niglintgak, Ivik, Kugpik, Kumak, Mayogiak) oil reserves could be developed early in a regional production scenario (see Figure 2).

Table 1. Additional discoveries of hydrocarbons - presented in the 1985-86 development scenario (Owen 1985).

Region	Field Type	Number (1985)	Number (2005)
Norman Wells	Oil	1	1
	Gas	0	0
Colville Lake	Oil	0	0
	Gas	0	3
Mackenzie Delta	Oil	4	8
	Gas	3	9
Beaufort Sea	Oil	3	11
	Gas	3	11

Seismic exploration will likely continue at present or perhaps increased rates in various parts of the MEMP study area. The scenario presented in Owens (1985) assumed that 2000-5000, 2000-20,000 and 7000-30,000 km of seismic lines would be surveyed per year in the Norman Wells, Colville Lake, and Mackenzie Delta areas, respectively, over the period from 1985 to 2005. Numerous factors will continue to influence the level of future exploration activity, most notably available land and exploration expenditures, world energy prices, the results of ongoing exploration efforts, and the presence or absence of transport systems to move potential discoveries to market.

Table 2 summarizes the number of exploration and production wells expected to be drilled in Norman Wells, Colville Lake, and Mackenzie Delta areas by the year 2005. These figures do not include additional wells that may be drilled in the offshore. The actual number of wells drilled will depend on the same factors described above for seismic operations.

Table 2. Additional exploration and production wells - presented in the 1985-86 development scenario (Owens 1985).

	Exploration		Production	
Region	1985	2005	1985	2005
Norman Wells	400+	575+	90	380
Colville Lake	7	242	0	135
Mackenzie Delta	146	525	0	490

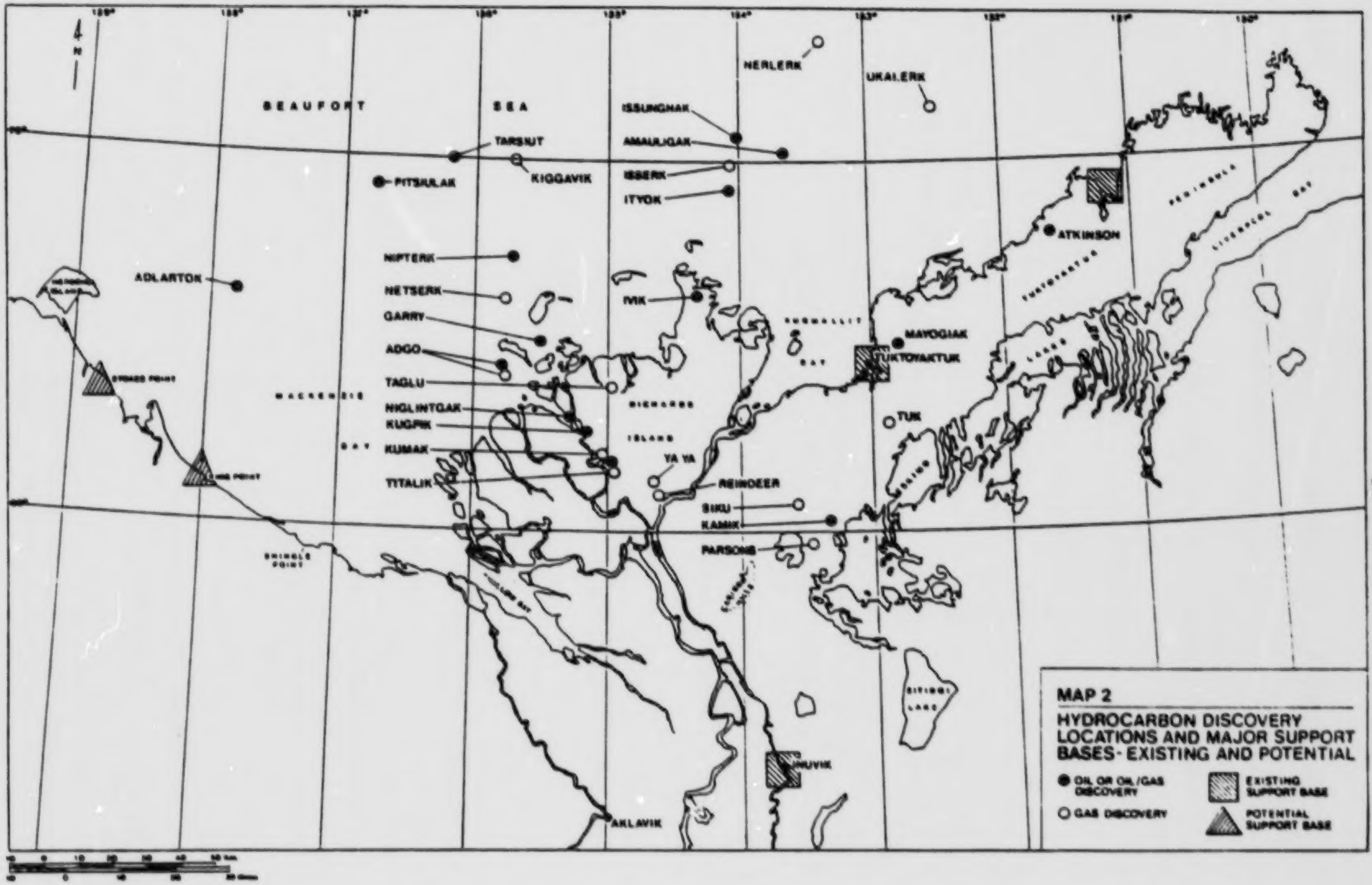

MAP 2
HYDROCARBON DISCOVERY LOCATIONS AND MAJOR SUPPORT BASES - EXISTING AND POTENTIAL
OIL OR OIL/GAS DISCOVERY
GAS DISCOVERY
EXISTING SUPPORT BASE
POTENTIAL SUPPORT BASE
BEAUFORT
SEA
NERLERK
UKALERK
ISSUNGNAK
AMAULIGAK
ISSERK
ITYOK
TARSIUT
KIGGAVIK
PITSIULAK
NIPTERK
NETSERK
GARRY
ADGO
TAGLU
NIGLINTGAK
KUGPIK
KUMAK
TITALIK
ADLARTOK
IVIK
YA YA
REINDEER
SIKU
KAMIK
PARSONS
MAYOGIAK
TUKTOYAKTUK
TUK
ATKINSON
INUVIK
AKLAVIK
MACKENZIE
BAY
RICHARDS
ISLAND
KUGMALLIT
BAY
SHINGLE POINT
N

Figure 2. Hydrocarbon discovery locations.

Oil and Gas Processing Facilities and Gathering Line Systems

There are no changes in the number of processing facilities and length of gathering line systems expected to be required to support oil and gas production in the MEMP study area. According to the scenario presented by Owens (1985) and assuming that the 914 mm Polar Gas pipeline is eventually constructed, three gas processing facilities would be required in the Delta. An additional central facility would also be required to process gas from the Colville Lake area if further exploration demonstrates adequate reserves in this region. Gathering line lengths for the Delta and Colville Lake areas are assumed to be 400 and 350 km, respectively (Owens 1985).

No further oil processing facilities or gathering line systems are assumed to be necessary in the Norman Wells region. However, two facilities are likely to be required to support oil production from the Delta, assuming a mid-sized oil pipeline is constructed. In addition, some processing facilities would also be required for any offshore fields prior to transport of oil out of the region in a pipeline down the Mackenzie Valley. The length of the gathering line system would likely vary from 150 to several hundred kilometres depending on the number and location of oil fields eventually brought into production.

Transport Systems

As indicated earlier, the long-term potential for hydrocarbon production from the MEMP study area and adjacent parts of the Beaufort Sea is contingent on the availability of suitable transport systems. The most likely scenario is construction of two pipelines from the Mackenzie Delta to southern Canada. The scenario presented in the 1985-1986 MEMP final report indicated that a gas pipeline (i.e., Polar Gas 914 mm diameter) would precede a mid-sized oil pipeline (324 mm diameter) by about 5 years. It was assumed that construction of the gas and oil pipelines would start in 1987 and 1992, respectively.

At present there is not agreement within the industry regarding the order in which the transport systems would be constructed. Some industry representatives believe that the oil and gas pipelines would be separated by a five-year period, irrespective of which system is constructed first. Others suggest that both pipelines could be constructed at the same time (although not in the same right-of-way) to allow some sharing of construction facilities. It has also been stated that the diameter of the oil pipeline may be larger than indicated in the Owens (1985) scenario.

Including the time required for engineering design and project approvals, it is expected that construction of either pipeline could require 6-7 years. Consequently, oil or gas production from the Delta or adjacent parts of the Beaufort Sea is not likely to occur until 1995-96 if a decision to proceed with either transport system is made within the next year.

As indicated in Owens (1985), Polar Gas has proposed the construction of a 914 mm (36 in) diameter high-pressure gas transmission line from the Mackenzie Delta to Edson, Alberta. The system is expected to have an initial capacity of 80 million cubic feet per day, but this could be increased through the addition of compression power, compression facilities or by looping. During the 2-3 year period when the pipeline is actually constructed, associated activities would include production drilling and the construction of central processing facilities and flowlines between the production pads (Owens 1985).

Unlike the Polar Gas proposal, a firm plan for construction of an oil pipeline from the Mackenzie Delta region has not yet been prepared. Nevertheless, it is anticipated that a mid-sized (400-600 mm diameter) system would be required to support production from both onshore and offshore reserves. A 610 mm (24 in) pipeline would allow a throughput of up to 220,000 bbls oil/day. It is probable that the pipeline would be constructed within the existing IPL corridor south of Norman Wells, although a new right-of-way would have to be cleared. Owens (1985) reports that the transport system would extend as far as Zama, Alberta. However, this assumes that there is sufficient capacity in the existing Rainbow system to transport Mackenzie Delta/Beaufort Sea oil to Edmonton, Alberta. If this is not the case at the time when oil production begins, it may be necessary to extend the new pipeline to Edmonton.

Offshore reserves would likely be transported to shore via a subsea pipeline system connecting one or more fields. Even if a single offshore field is sufficient to justify an oil pipeline, it can be assumed that other fields would eventually be brought onstream through a subsea gathering system. North Point on Richards Island is expected to be the preferred location to bring offshore oil ashore. The mainline system could then have any number of laterals or gathering lines to access oil from onshore reserves. If more oil reserves are discovered after the pipeline is in place, increased throughput may be achieved through the addition of more pump stations, looping or twinning. Depending on the line diameter and throughput, 8 to 16 pump stations may be required between the Delta and Zama Lake.

Support Systems

Support systems will be required for both construction and operation of oil and gas production facilities in the MEMP study area, although those in the construction phase will be more extensive. The primary support systems will be those required for transportation of materials and personnel to construction sites, although base and temporary construction camps would also be necessary for further development of oil and gas resources in the region.

As indicated in Owens (1985), shore based facilities and activities which will result from or support offshore development should be considered as part of MEMP. In the past, the primary support base has been Tuktoyaktuk, with secondary support facilities in Inuvik. Although the presence of the petroleum industry in both these communities has decreased substantially in the last three years, it is reasonable to assume that they would be sites of activity again with development of oil and gas reserves because of their importance as centres of transport and trans-shipment for the entire region. At the same time, smaller support bases previously active at Tununuk Point, Swimming Point, Point Farewell, and Pullen Island could be re-activated to support onshore as well as offshore development in the immediate vicinity of the Delta (Owens 1985).

Temporary camps would be established during the construction phase to provide accommodation and a base of operation for manpower required for installation of pipelines. Mobile camps would be located along pipeline spreads during each of the construction seasons. They would be self-contained facilities, with modular accommodation, a domestic water treatment facility, and a solid waste incinerator.

In the past, there has been considerable discussion of development of deep-water port facilities at either King Point or Stokes Point on the Yukon coast, as well as a potential haul road inland to a quarry site. The possibility of an all-weather road from the Dempster Highway to this deep-water port has also been discussed. At present, the petroleum industry appears to have less need for such a deep-water port, particularly if quarry rock for offshore drilling structures can be obtained from elsewhere in the region. However, in the absence of evidence to the contrary, it should be assumed that a Yukon coast shorebase may be necessary for long-term development of offshore hydrocarbon resources. On the other hand, the industry does not presently view a road link with the Dempster Highway as a necessary requirement for its operations.

Although not part of the hydrocarbon development scenario for the region, it is possible that the existence of a linear corridor in the Delta may promote construction of a highway from Inuvik to Tuktoyaktuk.

It is likely that most heavy equipment and bulk material necessary for construction of production facilities and pipelines would be transported into the region by barge down the Mackenzie River, although transport via all-weather and winter roads may be used in some parts of the MEMP study area. In some remote locations, helicopter lifts may be necessary for initial and resupply purposes. Fixed-wing aircraft may also be used for survey purposes and to transport personnel and lighter equipment to some construction sites.

A series of tables presented in Owens (1985) outline the type and anticipated intensity of support activities required for a 20-year hydrocarbon development scenario in the MEMP study area. Readers are referred to this appendix in the previous MEMP final report because assumptions regarding support necessary for continued exploration, production, and construction and operation of oil and gas pipelines remain valid.

PART II:

PERTINENT RESEARCH IN RELATION TO MEMP HYPOTHESES

INTRODUCTION

The following material describes each hypothesis in terms of suggested links and relationships. Recent research and studies pertinent to each hypothesis are then described. Some studies are relevant to a number of hypotheses. In these cases the study is reviewed in relation to the hypothesis that is most appropriate but other hypotheses within which the study should be considered are also listed.

It should be noted that results and general conclusions of particular studies are those of the original investigators. The role of the study team was to describe current research in terms of methods, results and conclusions whenever possible and then to comment on how these results could apply to MEMP hypotheses.

HYPOTHESIS NO. 1

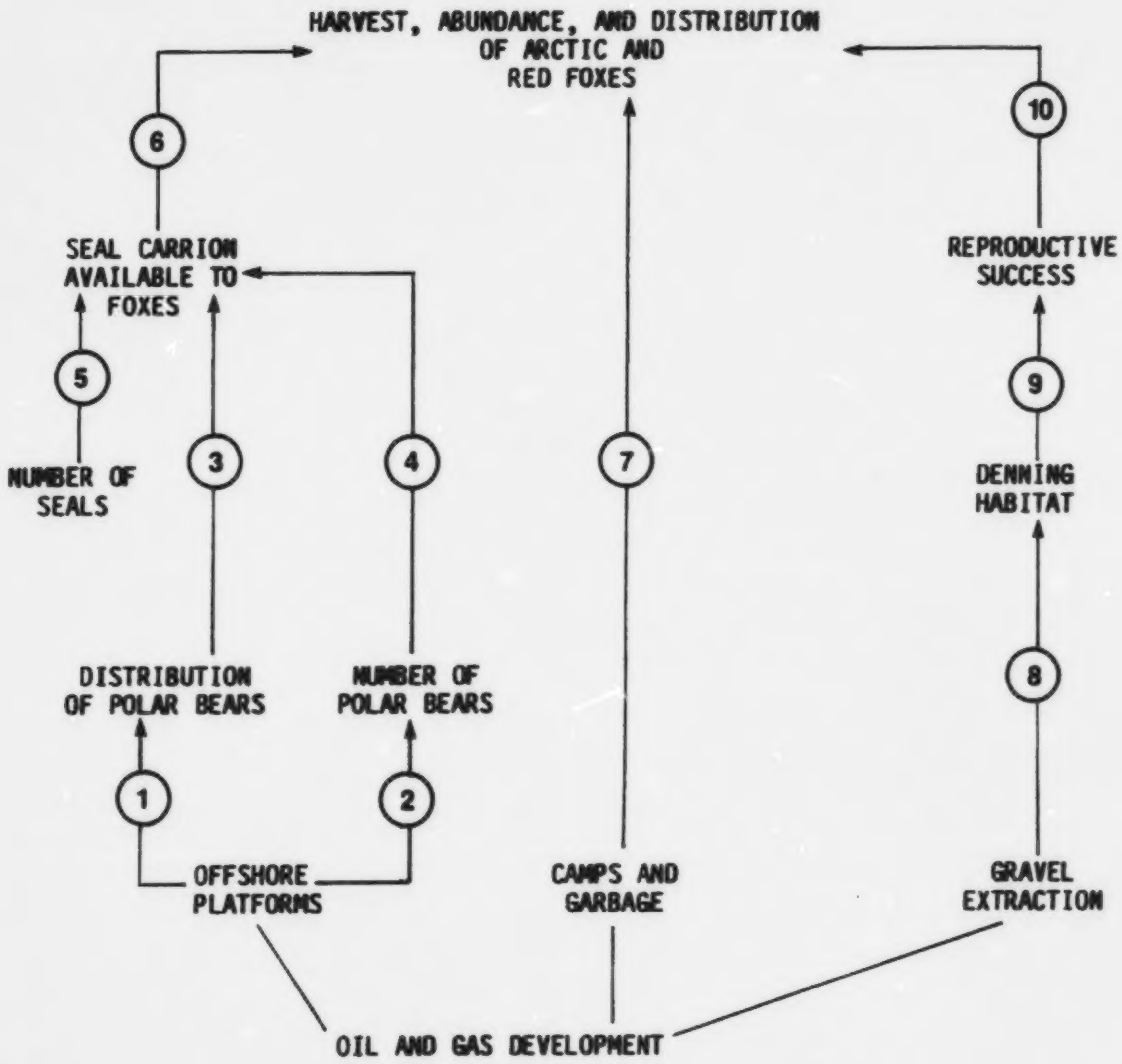
THE PRESENCE OF OFFSHORE DRILLING PLATFORMS, CONSTRUCTION CAMPS (AND ASSOCIATED GARBAGE) AND GRAVEL EXTRACTION WILL RESULT IN A DECREASE IN THE NUMBERS OF ARCTIC AND RED FOXES

For Hypothesis No. 1, the valued ecosystem components were arctic and red foxes. Conclusions reached were that this hypothesis was invalid for arctic foxes and unlikely for red foxes with respect to gravel extraction and possible, but of low significance with respect to garbage. Garbage treatment and education were recommended.

The following material covers nine project overviews relevant to this hypothesis.

HYPOTHESIS NO. 1

The presence of offshore drilling platforms, construction camps (and associated garbage) and gravel extraction will result in a decrease in the numbers of arctic and red foxes


HARVEST, ABUNDANCE, AND DISTRIBUTION OF ARCTIC AND RED FOXES
6
10
SEAL CARRION AVAILABLE TO FOXES
REPRODUCTIVE SUCCESS
5
9
NUMBER OF SEALS
3
4
7
DENNING HABITAT
DISTRIBUTION OF POLAR BEARS
NUMBER OF POLAR BEARS
8
1
2
OFFSHORE PLATFORMS
CAMPS AND GARBAGE
GRAVEL EXTRACTION
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Polar bears that encounter offshore platforms will subsequently be attracted to these facilities.

Link 2: Polar bears that approach offshore structures have to be controlled, and this will result in the need to destroy some bears.

Link 3: Changes in the distribution of polar bears will alter the distribution of seal carrion on the ice.

Link 4: A decrease in the number of polar bears will reduce the amount of seal carrion on the ice.

Link 5: A decrease in the number of seals due to offshore activities will reduce the amount of seal carrion.

Link 6: A decrease in the amount and change in the distribution of seal carrion will decrease the number of arctic foxes.

Link 7: The presence of camps and refuse will affect the abundance and distribution of arctic and red foxes.

Link 8: Gravel extraction activities will decrease the amount of denning habitat.

Link 9: A decrease in the amount of denning habitat will reduce the reproductive success of arctic and red foxes.

Link 10: Reproductive success influences the abundance and distribution of foxes.

MEMP PROJECT OVERVIEW NO. 1-1

TITLE:	Observations on foxes, Alopex lagopus and Vulpes vulpes, and wolves, Canis lupus, on the offshore sea ice of northern Labrador.
PRINCIPAL INVESTIGATORS:	D. Andriashek, H.P.L. Kiliaan and M.K. Taylor
AFFILIATION:	Canadian Wildlife Service and Faculty of Forestry, University of British Columbia
FUNDING SOURCE:	CWS, University of British Columbia
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 1

BRIEF PROJECT DESCRIPTION

Observations of arctic foxes, red foxes and wolves were made on the offshore sea ice in northern Labrador during late winter and early spring from 1975 to 1979 and again in 1982. Unknown numbers of red foxes, one arctic fox and one wolf were scavenging on ringed seals which had been killed by polar bears. Foxes showed a preference, as did polar bears for active ice areas and exposed coastlines. Some predation of ringed seal pups by arctic foxes occurred. Scavenging of unused seal remains and predation of newborn pups is probably important to survival of foxes and may also be significant to wolves along the northern Labrador coast.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report is related to Hypothesis 1, Link 6 which states that "a decrease in the amount and change in the distribution of seal carrion will decrease the number of arctic foxes." This study provides further data on the degree to which arctic foxes feed on seal carrion during winter and spring. It also documents red foxes feeding on seal carrion.

MEMP PROJECT OVERVIEW NO. 1-2

TITLE: Arctic fox den survey - Herschel Island, July 24-28, 1986.

PRINCIPAL INVESTIGATOR: B.G. Slough

AFFILIATION: Fish and Wildlife Branch, Yukon Department of Renewable Resources

FUNDING SOURCE: NOGAP

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 1

BRIEF PROJECT DESCRIPTION

Results of a brief survey of fox dens located during 1985 are reported, including reports on den activity, prey and a brief summary of fox history on Herschel Island.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is of marginal relevance to MEMP Hypothesis 1, Link 8 (denning habitat) and Link 10 (reproductive success influences the abundance and distribution of foxes.) Den surveys provide a partial measure of the distribution and abundance of foxes.

MEMP PROJECT OVERVIEW NO. 1-3

TITLE:	Physical characteristics, terrain associations and soil properties of arctic fox (*Alopex lagopus*) dens in northern Yukon Territory, Canada.
PRINCIPAL INVESTIGATORS:	C.C.M. Smits, C.A.S. Smith and B.G. Slough
AFFILIATION:	Fish and Wildlife Branch, Yukon Department of Renewable Resources.
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 1

BRIEF PROJECT DESCRIPTION

Physical and soil characteristics of arctic fox dens on Herschel Island and the Yukon Coastal Plain are described. Distribution is related to terrain map units within the study area. The non-random association of fox dens with certain landforms facilitates the use of existing terrain maps in making land use planning decisions.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is related to Link 8 of Hypothesis 1 which states that "gravel extraction activities will decrease the amount of denning habitat." This study attempts to further define the terrain characteristics that are used by arctic foxes for den site locations. The degree to which terrain that is suitable for fox den sites overlaps with gravel extraction sites will determine the extent of denning habitat loss suffered by arctic foxes.

MEMP PROJECT OVERVIEW NO. 1-4

TITLE: Lisburne Terrestrial Monitoring Program - 1986. The effects of the Lisburne Development Project on geese and swans.

PRINCIPAL INVESTIGATORS: S.M. Murphy, B.A. Anderson, C.L. Croner and R.H. Day

AFFILIATION: Alaska Biological Research, Inc.

FUNDING SOURCE: ARCO Alaska, Inc.

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No. 1

BRIEF PROJECT DESCRIPTION

The distribution of fox sightings and active den sites was documented during summer 1986 in the Lisburne Development Area (LDA). Arctic foxes were observed in all parts of the LDA, whereas red fox sightings were clustered in a sand dune area and in a brant colony. However, the authors suspected that only one red fox was present in the study area.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report is relevant to Hypothesis 1, Link 7, which states that "the presence of camps and refuse will affect the abundance and distribution of arctic and red foxes." The authors located arctic and red foxes throughout the Lisburne Development Study area. They also found three arctic fox dens at varying distances from industrial developments. These distributional data are presented, but were not analysed relative to developments.

MEMP PROJECT OVERVIEW NO. 1-5

TITLE: Ecological factors influencing the distribution of ringed seals during the open water period in the southeastern Beaufort Sea.

PRINCIPAL INVESTIGATOR: L. Harwood

AFFILIATION: University of Alberta

FUNDING SOURCE: DFO, INAC, Boreal Institute, U.S. M.M.S., ESRF, CWS

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 1

BRIEF PROJECT DESCRIPTION

M.Sc. Thesis (in preparation) examines patterns of aggregation in ringed seals from aerial survey data collected during 1982 and 1984-1986. Group sizes and regional dispersion are discussed. Aggregations of 5,000 to 15,000 seals occurred each year; however, the locations of these aggregations varied from year to year.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 1, Link 5, states that "a decrease in the number of seals due to offshore activities will reduce the amount of seal carrion." The relevance of this project to MEMP is minimal due to the fact that it considers seal distribution during the open water period, whereas seal carrion is available to foxes only during the portion of the year when the Beaufort Sea is ice-covered. However, to the extent that the open water distribution reflects winter distribution of seals, this study provides some useful information.

MEMP PROJECT OVERVIEW NO. 1-6

TITLE: Distribution and abundance of seals in the Beaufort Sea, Amundsen Gulf and Prince Albert Sound, 1984.

PRINCIPAL INVESTIGATOR: M.C.S. Kingsley

AFFILIATION: Department of Fisheries and Oceans

FUNDING SOURCE: ESRF

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 1

BRIEF PROJECT DESCRIPTION

Aerial surveys were flown during 1984 to assess the distribution and abundance of seals in relation to oil and gas development in the Beaufort Sea and adjacent waters.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 1, Link 5, which states that "a decrease in the number of seals due to offshore activities will reduce the amount of seal carrion." The results of this study showed that there were no significant affects of industrial disturbance on seals. This report supports the conclusion of the workshop participants that "it is unlikely that offshore activity will significantly affect ringed seal populations . . . [or] that development would reduce the availability of seal carrion to arctic foxes".

MEMP PROJECT OVERVIEW NO. 1-7

TITLE:	Tagging and movements of polar bears in the Beaufort Sea.
PRINCIPAL INVESTIGATOR:	I. Stirling
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	NOGAP
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 1

BRIEF PROJECT DESCRIPTION

Report in preparation to summarize the results of three years of NOGAP studies on polar bears. Interim results are presented in internal CWS reports that were not made available to us by the author. This tagging study of polar bears attempts to document the distribution, abundance and movements of bears in relation to development activities in the Beaufort Sea.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

These studies relate to Hypothesis 1, Links 1 and 3, which concern the distribution and behaviour of polar bears related to offshore oil and gas activity in the Beaufort Sea.

MEMP PROJECT OVERVIEW NO. 1-8

TITLE: Attraction of polar bears to offshore rigs.

PRINCIPAL INVESTIGATOR: I. Stirling

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: CWS

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 1

BRIEF PROJECT DESCRIPTION

Results of polar bear tagging studies have been analysed to assess the attraction of bears to offshore drilling rigs in the Beaufort Sea. General results suggest that polar bears are attracted to offshore rigs because seals tend to concentrate in areas of open water on the "downstream" side of offshore rigs in winter.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This paper specifically addresses the attraction of polar bears to offshore platforms, and therefore, relates to Hypothesis 1, Link 1, which states that "polar bears that encounter offshore platforms will subsequently be attracted to these facilities."

HYPOTHESIS NO. 2

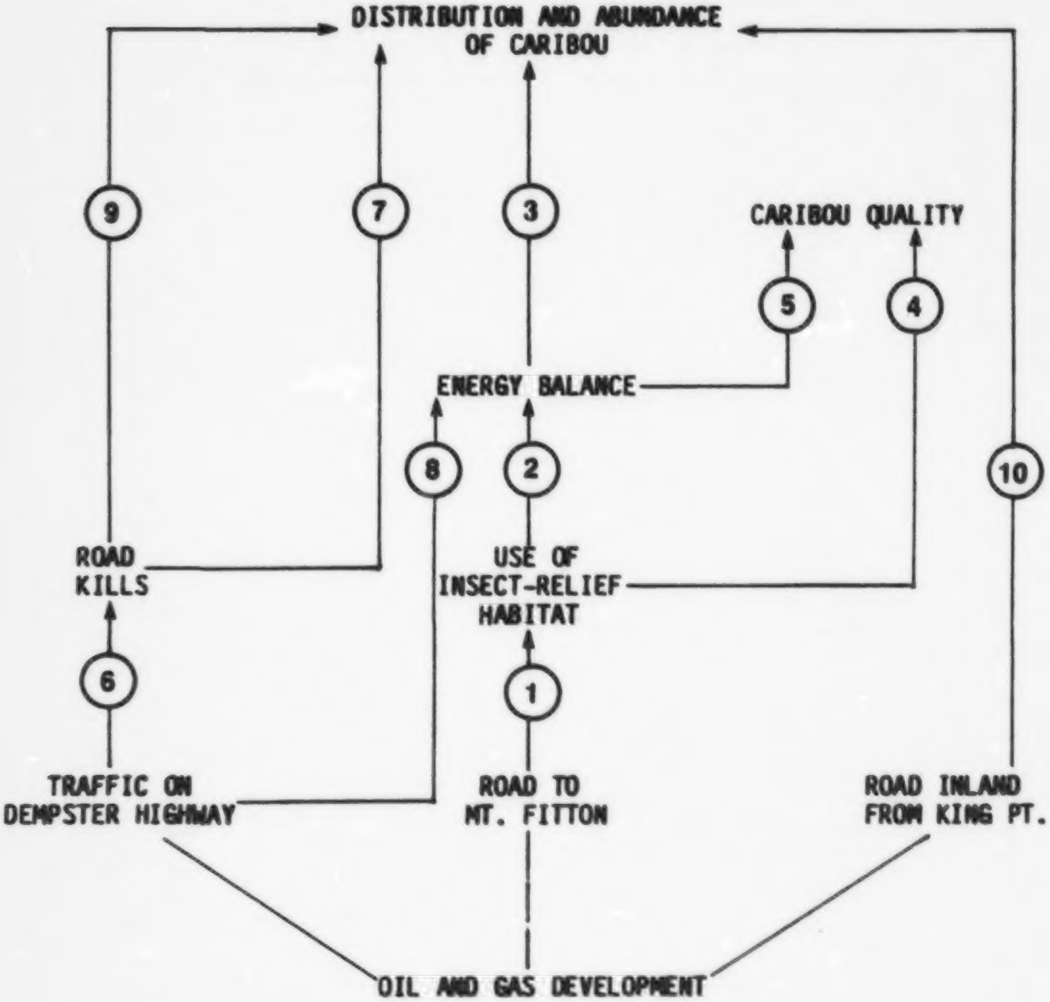
INCREASED TRAFFIC ON THE DEMPSTER HIGHWAY AND ROADS ON THE NORTH SLOPE WILL DECREASE THE NUMBER OF CARIBOU AND ALTER THEIR DISTRIBUTION

For Hypothesis No. 2, the valued ecosystem component was caribou. Conclusions reached indicated that this hypothesis was likely valid. Studies on the effects of road traffic on caribou movements and distribution were recommended. Baseline research on the effects of insect harassment on caribou activity and body condition and their significance to survival are required before the effects of road traffic on caribou can be adequately assessed. Monitoring of road kills and the effects of traffic along the Dempster Highway and the proposed North Slope roads were also recommended.

The following material covers 21 project overviews relevant to this hypothesis.

HYPOTHESIS NO. 2

Increased traffic on the Dempster Highway and roads on the North Slope will decrease the number of caribou and alter their distribution


DISTRIBUTION AND ABUNDANCE OF CARIBOU
9
7
3
CARIBOU QUALITY
5
4
ENERGY BALANCE
8
2
10
ROAD KILLS
USE OF INSECT-RELIEF HABITAT
6
1
TRAFFIC ON DEMPSTER HIGHWAY
ROAD TO MT. FITTON
ROAD INLAND FROM KING PT.
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Traffic on the proposed road inland to Mt. Fitton (or through Blow Pass) could act as a barrier to a large segment of the Porcupine caribou herd and prevent animals from reaching insect-relief areas in the northern Richardson Mountains in late July and early August.

Link 2: Restricted access to insect-relief areas will increase the daily energy requirements associated with insect avoidance, reduce fat storage in the fall and may also result in an increased incidence of parasites in caribou.

Link 3: Lower energy levels will result in decreased calving success, lower calf survival and, therefore, lower numbers of caribou.

Link 4: Reduced access to insect-relief habitat will increase the incidence of parasites and reduce the quality of caribou hides.

Link 5: Decreased animal fat levels will reduce the quality of caribou meat and hides.

Link 6: Increased traffic on the Dempster Highway will increase the number of caribou killed as a result of collisions with vehicles.

Link 7: Road kills on the Dempster Highway will decrease the abundance of caribou.

Link 8: Increased traffic levels on the Dempster Highway will harass caribou and increase energy expenditure.

Link 9: Increased traffic on the Dempster Highway will act as a barrier and prevent access of caribou to habitat south of the highway.

Link 10: Traffic on the proposed road inland from King Point could act as a barrier to the bull/barren cow segment of the herd and force animals to travel a greater distance to reach the large post-calving aggregations of caribou.

MEMP PROJECT OVERVIEW NO. 2-1

TITLE:	Migratory movements and the Nelchina caribou herd in relation to the Trans-Alaska Pipeline.
PRINCIPAL INVESTIGATORS:	D.R. Carruthers and R.D. Jakimchuk
AFFILIATION:	D.R. Carruthers and Associates, and Renewable Resources Consulting Services Ltd.
FUNDING SOURCE:	Alyeska Pipeline Serv. Co.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

The crossing behaviour of the Nelchina caribou herd along the Trans-Alaska Pipeline was studied during the spring and fall from 1981 to 1983. The major objective was to compare the current crossing locations of the herd during spring and fall migration to those prior to construction of the pipeline.

Of an estimated 7,909 caribou that were recorded on the pipeline right-of-way, all crossed the pipeline except for four caribou. During the spring and fall, 49% of the caribou crossed at a pipe above ground, 29% of these caribou crossed at a special crossing structure.

The results showed that the caribou used the traditional migration routes as described prior to pipeline construction. Migration routes were found to be associated with topography and terrain features rather than pipeline characteristics. Response of caribou to vegetation type, pipe mode or height at crossing sites was variable. The authors concluded that the presence of the pipeline did not appear to affect the traditional migration of the Nelchina caribou herd.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is relevant to the validity of the linkages of Hypothesis 2 that deal with the alteration of distribution as a result of the barrier effect of road traffic. The conclusions of the study were that the pipeline did not affect the traditional migration routes of the herd.

MEMP PROJECT OVERVIEW NO. 2-2

TITLE:	Differential habitat use and sexual segregation of the Central Arctic caribou herd.
PRINCIPAL INVESTIGATORS:	R.D. Jakimchuk, S.H. Ferguson and L.G. Sopuk
AFFILIATION:	Renewable Resources Consulting Services Ltd.
FUNDING SOURCE:	Alyeska Pipeline Serv. Co.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

A three year study on the Central Arctic caribou herd initiated in 1981 was conducted to monitor the caribou after construction of the Trans-Alaska pipeline system. Distribution of caribou in relation to riparian habitats was determined by calculating habitat preference values.

During most of the annual cycle of the herd, distribution was found to be characterized by sexual segregation and differential habitat use by males and females. During all seasons except the pre-rut and rut periods, male caribou made greater use of riparian habitats than did females. The authors theorized that the low use of riparian habitats by calving cows may be related to predator avoidance strategies. Their hypothesis that predator avoidance may have an overriding influence on the distribution of females during spring and calving was supported by the use of snow-covered areas remote from river valleys for calving by females observed in this study. It was theorized that the preference of male caribou for riparian habitat may be related to optimal foraging strategies.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is pertinent to testing the validity of Hypothesis 2 dealing with traffic effects on the movement and distribution of caribou. The cows and calves of the Central Arctic caribou herd on the Arctic Coastal Plain may not be avoiding the Trans-Alaska Pipeline corridor area due to the presence of development. It may be a result of avoidance of riparian habitat found in the corridor.

MEMP PROJECT OVERVIEW NO. 2-3

TITLE: The relationship of caribou summer distribution and the Trans-Alaska Pipeline: does absence mean displacement?

PRINCIPAL INVESTIGATORS: R.D. Jakimchuk

AFFILIATION: Renewable Resources Consulting Services Ltd.

FUNDING SOURCE: Arctic National Wildlife Refuge, Alaska Coastal Plain Resource Assessment, U.S. Dept. of the Interior.

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

This paper discusses the most significant findings which encompass the period prior to and following development of the Trans-Alaska Pipeline corridor. The author states that if the factors affecting pre- and post-calving distributions are examined, strong well-documented ecological reasons can explain the observed distributions of caribou. Several previous studies concluded that calving caribou have been displaced from the Prudhoe Bay Oilfield. However, the author presents considerable evidence that Prudhoe Bay was not an important calving area prior to development. In addition, the author disagrees with the interpretation of why calf percentages are lower along the Trans-Alaska Pipeline corridor. Evidence that sexual segregation and differential habitat use result in different distribution of cow/calf and bull groups is well documented.

The author concluded that cow/calf groups are not avoiding the Trans-Alaska Pipeline but instead were avoiding the major river valley associated with the pipeline corridor.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report should be considered when determining the validity of Hypothesis 2. The hypothesis states that increased traffic will reduce caribou number and alter their distribution. This paper is also of value in evaluating the results of many of the studies reviewed in regard to Hypothesis 2.

MEMP PROJECT OVERVIEW NO. 2-4

TITLE:	Dynamics of caribou and wolves in Denali National Park.
PRINCIPAL INVESTIGATOR:	F.J. Singer
AFFILIATION:	National Park Service
FUNDING SOURCE:	NPS
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

An extensive review of records was conducted to document the decline of the Denali caribou herd in Alaska and to determine the factors that caused the decline.

The review found no correlation between the two major population declines in caribou and developments in the park or visitation increases. Although there were a number of changes in migration routes, these changes were not obviously related to avoidance of humans. The largest increase in park road traffic occurred in 1972 but caribou migrations past the road corridor were consistent until at least 1981.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This comprehensive review is relevant to Hypothesis 2 of the MEMP project in that it reviewed the effects of human disturbance on caribou over approximately 80 years and could find no evidence of human disturbance causing the declines in population of the herd.

MEMP PROJECT OVERVIEW NO. 2-5

TITLE: Movement patterns of the Porcupine caribou herd in relation to oil development.

PRINCIPAL INVESTIGATORS: K.R. Whitten and W.L. Regelin

AFFILIATION: ADF&G

FUNDING SOURCE: Federal Aid

EXPECTED COMPLETION DATE: Unknown

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

The objectives of this study are to identify migration routes between summer and winter ranges and to determine movement patterns in relation to topographic features and broad habitat types on the Arctic Coastal Plain. The study is part of a cooperative program between the Alaska Office of Research, U.S. Fish and Wildlife and the Alaska Department of Fish and Game. The overall goals of the project are to identify potential conflicts between caribou and oil development and to recommend mitigative measures.

As of November 1987, 11 adult female caribou from the Porcupine herd and 10 from the Central Arctic herd have been equipped with both satellite (PTT) and standard radio collars. A PTT is created for each location fix that includes date, location, slope, aspect, vegetation type, ambient temperature and activity of the caribou. Migration routes will be determined from the satellite data and compared with routes used by other members of the herd (determined by trail systems). Location of calving areas are determined and correlated to habitat types and terrain features to determine any preferences. Specific areas used during periods of insect harassment will also be determined and any distinguishing characteristics of the areas will be noted. The data are in the process of being analysed.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is very important to the determination of the validity of Hypothesis 2 and the impacts of oil development as a whole on the Porcupine caribou herd. The results of this study will contribute significantly to the knowledge of the herd and effects of oil development.

MEMP PROJECT OVERVIEW NO. 2-6

TITLE: Daily energy budgets of caribou: a simulation approach.

PRINCIPAL INVESTIGATOR: S.G. Fancy

AFFILIATION: University of Alaska

FUNDING SOURCE: U. Alaska

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

The objective of this study was to investigate ways in which energetic constraints affect caribou morphology, physiology and behaviour. A computer simulation model was developed to allow prediction of energetic changes during the year under various conditions. The model was used to simulate daily energy budgets of caribou during late winter, spring migration and during insect harassment. Data from several studies on wild caribou and results of the author's research on captive caribou were used as a database. The data for spring migration simulation used results of studies that dealt with the Porcupine caribou herd. Energy costs were determined for caribou activities and conditions such as locomotion, feeding, standing, pregnancy and lactation during the three different study periods.

The author concluded that the model was a useful tool for predicting changes in a caribou's energy budget under different conditions. The model revealed the importance of factors related to energy intake on energy budgets as opposed to factors associated with energy expenditure.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This thesis is of interest in determining the validity of Hypothesis 2. This study is applicable to Links 2 and 8 which are related to energy expenditure of caribou.

MEMP PROJECT OVERVIEW NO. 2-7

TITLE: Effects of a road system on caribou distribution during calving.

PRINCIPAL INVESTIGATORS: J.R. Dau and R.D. Cameron

AFFILIATION: University of Alaska and Alaska Department of Fish and Game

FUNDING SOURCE: U. Alaska, ADF&G

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

To determine the effects of a road system on the local distribution of the Central Arctic caribou herd, comparisons were made between surveys conducted four years prior to and four years after road construction. The roads were constructed in the winter of 1981-1982 and, in the winter of 1984-1985, a pipeline was erected alongside one of the roads.

During the post-construction period (1982-1985) significantly fewer caribou were observed in the study area than during pre-construction (1978-1981). The relationship between caribou density and distance from roads was also significantly different between the two periods. In the post-construction period, density of caribou and calf numbers were correlated with distance from roads. There was no relationship between these parameters found in the pre-construction period. The authors stated that results indicated that the distribution of maternal caribou was not appreciably different from that of all caribou. However, they found that there was a high positive correlation between the density of maternal females and the distance from roads. The authors concluded that the results suggested that there had been a local displacement of maternal caribou in response to roads and human activity.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study discusses the effect of a road system on caribou distribution and is, therefore, directly applicable to whether or not Hypothesis 2 is valid. One of the major components of the hypothesis is that increased traffic will alter the distribution of caribou. This study is of particular relevance since it is one of the few reports that covered research both before and after construction of a road system. Although the authors concluded that maternal caribou are displaced by the road, they did not mention that the overall density of caribou increased markedly during the study period despite the presence of intensive oilfield development.

MEMP PROJECT OVERVIEW NO. 2-8

TITLE:	The effects of pipelines, roads and traffic on the movements of caribou (*Rangifer tarandus*).
PRINCIPAL INVESTIGATORS:	J.A. Curatolo and S.M. Murphy
AFFILIATION:	Alaska Biological Research
FUNDING SOURCE:	Kuparuk River Unit owners
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

This study was conducted during periods of high insect abundance between 1981 and 1983 in the Kuparuk and Prudhoe Bay oilfields on the Arctic Coastal Plain. To determine the frequency of caribou crossing roads, pipelines and pipelines along roads, 7 study sites were used; 2 were associated with a road and pipeline, 2 with a pipeline, 1 with a road, and 2 were control sites. Data collected from observations of the Central Arctic caribou herd included group size, group composition, route of travel, reactions while crossing road or pipeline and number of vehicles in study site. Air temperature, wind speed and insect presence were also measured.

Caribou readily crossed over a road or under an elevated pipeline with frequency similar to the control sites. But where a pipeline paralleled a road, the frequency of crossings was significantly less than expected. Crossing frequencies of a pipeline adjacent to a road with traffic during insect-free periods and mosquito harassment periods was significantly less than expected but there was no significant difference during oestrid fly harassment periods. The authors suggested that the amount of vehicular traffic along a pipeline is important since caribou need sufficient time between vehicle encounters to cross both structures when placed alongside each other. They postulated that vehicles act in a synergistic fashion with a pipeline to produce a negative stimulus resulting in decreased crossing frequency.

The study found no significant difference between the percentage of cow-calf groups and bull groups that crossed the pipeline. This may have been a result of the intensity of drive to reach coastal insect-relief habitat.

Although the crossing frequency was low, ramp crossings were higher than expected. The authors commented that this preference reflects the effect of elevated pipelines on caribou behaviour; the visual stimulus of the elevated pipeline is gone once a ramp is reached. Caribou crossing under elevated pipelines did not select for any particular pipeline height between those studied (152-432 cm).

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of this study are pertinent to Hypothesis 2 dealing with the effects of increasing traffic on the Porcupine caribou herd. Several linkages (i.e., Links 6, 7, 8 and 9) of the hypothesis are involved in the conclusions of the study.

MEMP PROJECT OVERVIEW NO. 2-9

TITLE:	Oil pipeline crossing sites utilized in winter by moose, (Alces alces) and caribou (Rangifer tarandus) in southcentral Alaska.
PRINCIPAL INVESTIGATORS:	S.H. Eide, S.D. Miller and M.A. Chihuly
AFFILIATION:	Alaska Department of Fish and Game
FUNDING SOURCE:	ADF&G
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 2 and 5

BRIEF PROJECT DESCRIPTION

During the first winter of operation of the Trans-Alaska Pipeline, crossing sites of caribou and moose were studied along a 145 km segment of the pipeline. This segment of the pipeline and the Richardson Highway intersect the Nelchina caribou herd's migratory route to calving grounds and wintering areas. Analyses were conducted on the frequency distribution of vertical clearances where animal tracks were encountered, compared to the frequency distribution overall of vertical clearance. Analyses were also conducted to compare the proportion of buried pipeline to that which was elevated.

Most of the caribou that encountered the pipeline were migratory animals. The results of the vertical height comparisons showed that the caribou tended to show negative selection for vertical clearances. Few encounters resulted in deflections from the pipeline (2.7%). Caribou showed highly significant selection for buried pipeline sections compared to elevated selection. This may only reflect the fact that buried sections were placed where caribou were known to traditionally cross during migration. The data also did not reveal any evidence that caribou showed any selection for the short, specially-designed elevated crossing sites.

Most of the Nelchina caribou herd has crossed the Richardson Highway and the adjacent pipeline corridor in most years since the construction of the pipeline. The herd has also increased from 14,000 in 1977 to 25,000 in 1983. The authors stated that the above data indicate that the herd has increased despite any disruptions to their migratory movements that may have resulted from the presence of the pipeline.

In their discussion the authors explain the difficulty in demonstrating selection by the caribou for or against pipeline characteristics.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study has relevance to testing the validity of Hypothesis 2 dealing with the Porcupine caribou herd and increased traffic on roads. Although this study does not deal directly with the effects of roads on caribou, it can be used as a general reference relating to the effects of man-made barriers and the potential alteration or disruption of caribou movement.

MEMP PROJECT OVERVIEW NO. 2-10

TITLE: Influence of the Dempster Highway on the activity of the Porcupine caribou herd.

PRINCIPAL INVESTIGATORS: D.E. Russell and A.M. Martell

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: CWS

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

The impact of the Dempster Highway on the winter activity patterns of the Porcupine caribou herd was examined in this study. For the winter of 1979-1980 to 1981-1982 the potential disruption of activity was measured by daily activity pattern, cratering activity and short-term disruption by vehicles. Comparisons were made of the daily activity patterns of the caribou associated with the highway and those not associated with the highway. Cratering activity was quantified by continuous, timed observations of the behaviour of individual caribou. Differences in cratering parameters were examined between on and off-road caribou. Vehicle interaction studies in October 1980 involved scanning bands of caribou disturbed by vehicles.

Of the activity budgets examined between paired observations on and off the highway, only one was found to be significantly different; animals spent more time sparring off the road than those associated with the highway. Few significant differences were found between on and off road cratering activity and none were consistent. The three examples of short-term disruption by vehicles did not indicate any general response of caribou. The authors stated that, overall, the data indicated that no significant energetic disruption could be attributed to the Dempster Highway.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of this study provide evidence that is directly applicable to Hypothesis 2 and especially those linkages that involve energy budgets of the caribou. The hypothesis states that increased traffic will reduce caribou numbers and alter their distribution. This study deals with the Porcupine herd and the Dempster Highway both of which are components of the hypothesis.

MEMP PROJECT OVERVIEW NO. 2-11

TITLE: Movement and behaviour of the Burwash caribou herd relative to the proposed Alaska Highway Gas Pipeline.

PRINCIPAL INVESTIGATORS: D.A. Gauthier, W.K. Brown and J.B. Theberge

AFFILIATION: Yukon Department of Renewable Resources and University of Waterloo

FUNDING SOURCE: Yukon Dep. Renewable Res. and Univ. Waterloo

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

A major study objective was to assess the potential disturbance caused by construction and operation of the proposed pipeline on the caribou herd. The study was conducted between September 1978 and June 1982 in the St. Elias Mountains, southwestern Yukon. The herd occupied two distinct seasonal home ranges. The occupation of three ranges by different proportions of the herd varied consistently between seasons and years. The two subregions are separated by the Shakwak Trench through which three right-of-ways are located (Alaska Highway, Haines-Fairbanks Oil Pipeline, cleared right-of-way of proposed pipeline). Movement of caribou between these areas necessitated crossing of these right-of-ways. Regular, seasonal cross-Trench movements by the caribou were not prevented by these right-of-ways although some caribou that entered the Trench returned without crossing. The data obtained from radio-collared caribou indicated that the proportion of animals that did not make a complete crossing was small. The study also concluded that a minimal amount of time was spent by the caribou in the Trench during crossing. Most of the travel routes through the Trench appeared to be relatively direct with little deviation from the initial course. Most often, the caribou climbed or descended road berms up to 2.5 m in height directly without attempting to deviate. Only one group of 4 caribou was noted to stop and aggregate before crossing the right-of-way. Of the 39 radio-collared caribou in the study, 29 crossed the Trench for a total of 96 times during the study.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is related to Hypothesis 2 which deals with the Porcupine caribou herd and the effects of increased traffic, and especially to Linkages 1 and 10 of the hypothesis. Link 1 deals with traffic on the proposed road to Mt. Fitton acting as a barrier, preventing the herd from reaching insect-relief areas. Link 10 also discusses the proposed road as acting as a barrier forcing animals to travel a greater distance to reach the large post-calving aggregations.

MEMP PROJECT OVERVIEW NO. 2-12

TITLE:	Distribution of caribou calving in relation to the Prudhoe Bay oilfield.
PRINCIPAL INVESTIGATORS:	K.R. Whitten and R.D. Cameron
AFFILIATION:	Alaska Department of Fish and Game
FUNDING SOURCE;	ADF&G
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

This paper summarizes the results of intensive surveys conducted on the calving grounds of the Central Arctic caribou herd in June from 1978 through 1982. Weather had a major influence on the use of the coastal plain for calving. The density of caribou was highest near the coast, an area of relief from insect harassment. In the Prudhoe Bay region considerable calving occurred south of the oilfield but little was noted within it in all years of the study. Mean densities of caribou in five other calving ground regions were 2 to 18 times higher than those found at Prudhoe Bay. The study concluded that the oilfield had displaced calving of the Central Arctic caribou herd. However, the herd has increased rapidly since 1978. The Prudhoe Bay area may also be relatively unimportant as a calving ground due to poor drainage conditions and the availability of suitable uncrowded high-quality habitat adjacent to the area. As a result of the low density of the Central Arctic herd on its calving grounds, it was suggested that the herd has greater flexibility in selecting calving grounds than other caribou herds. The authors concluded that the herd must increase substantially and/or development must expand substantially before any serious consequences could reasonably be expected.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study can be used to assist in the testing of Hypothesis 2. It is related to the effects of disturbance on caribou caused by development of the Prudhoe Bay Oilfield and whether the distribution of the caribou is affected.

MEMP PROJECT OVERVIEW NO. 2-13

TITLE: Factors affecting pipeline crossing success of caribou.

PRINCIPAL INVESTIGATORS: W.T. Smith and R.D. Cameron

AFFILIATION: Alaska Department of Fish and Game

FUNDING SOURCE: ADF&G

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

A 32 km (10 km road only; 22 km road/pipeline complex) transect of West Sak Road was surveyed systematically during the summers of 1981 and 1982. For each caribou sighting, time, location, distance from the road, movements, local traffic and construction activity was recorded. Insect activity was also determined. Observations indicated that crossing success by caribou was influenced by factors such as pipeline design, caribou group structure and environmental stimuli.

Patterns of successful and attempted crossings of the road/pipeline complex were varied between and within years. The crossing activities were apparently related to insect harassment (the road/pipeline complex lies between coastal insect-relief areas and inland feeding areas). Most crossing attempts of the complex in 1981 and 1982 were during moderate or severe insect harassment. During oestrid fly harassment the percentage of successful crossings was significantly higher than during mosquito season. The authors stated that their results indicated that when oestrid flies are present the caribou's ability to negotiate roads and pipelines increased substantially. They also remarked that the long-term effects of disruptions of social bonds and group cohesion during crossing attempts are difficult to evaluate. Crossing success decreased with group size on both an individual and group basis.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Links 1, 2 and 4 of Hypothesis 2 deal with the effects of two North Slope roads on the Porcupine caribou herd. Traffic on the roads may disrupt movements to insect-relief habitat resulting in an increase in the daily energy requirements of caribou and increasing the incidence of parasites. The validity of these linkages can be determined by taking into consideration the results of this report.

MEMP PROJECT OVERVIEW NO. 2-14

TITLE:	Reactions of large groups of caribou to a pipeline corridor on the Arctic coastal plain of Alaska.
PRINCIPAL INVESTIGATORS:	W.T. Smith and R.D. Cameron
AFFILIATION:	Alaska Department of Fish and Game
FUNDING SOURCE:	ADF&G
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

This report describes the observations during the summer of 1981 and 1982 of two large groups of mosquito-harassed caribou that were observed for response to the road/pipeline complex near Prudhoe Bay. Of the original group of 917 caribou observed in 1981, it was estimated that 59% crossed either elevated pipeline sections (without recrossing) or buried pipeline sections. Twenty-two percent trotted or ran parallel to the pipeline for 32 km without crossing, while approximately 19% could not be accounted for. A group of 655 caribou was observed in 1982. Of this group, 63% crossed the pipeline/road complex and an estimated 37% separated from the main group and could not be accounted for.

In the discussion, the authors state that of 38 groups greater than 100 individuals observed during systematic surveys, only 8% (3 groups) attempted to cross the complex. They concluded that elevated pipelines prevent mosquito harassed groups of caribou from crossing readily. They discussed the substantial increase in energy expenditure as a result of interactions with the pipeline. As an example, they stated that 20% of the original group in 1981 ran or trotted 32 km along the pipeline. They also reported that the progressive fragmentation of groups may have increased the net susceptibility of individuals to insect attack. Combining data for both years showed that caribou were more successful in crossing buried sections compared to elevated sections of pipeline but it was not possible to determine what factors contributed to this preference.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study has relevance to the acceptance or rejection of Hypothesis 2 which states that increasing traffic will decrease the number of caribou and alter their distribution. The study is indirectly related to the linkages that deal with energy budgets and increased incidence of parasites. Note that in addition to intensive traffic, there was an elevated pipeline adjacent to the road with surface-to-pipe clearances of only 1.5 m in most areas.

MEMP PROJECT OVERVIEW NO. 2-15

TITLE:	Effects of the Trans-Alaska pipeline on the distribution and movements of caribou.
PRINCIPAL INVESTIGATORS:	R.D. Cameron, K.R. Whitten and W.T. Smith
AFFILIATION:	Alaska Department of Fish and Game
FUNDING SOURCE:	Federal Aid
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

This report highlights the results of aerial and highway surveys conducted between 1979 and 1982. The objectives of the study were to determine crossing locations, seasonal and annual changes in the distribution and group composition in the Trans-Alaska Pipeline corridor and to characterize responses of caribou to disturbance.

Rates of caribou sightings over the study period were found to vary considerably on a regional basis among years and seasons. There were some consistencies including lower fall sighting rates than summer and spring rates and summer sighting rates were highest along the northern half of the road. Aerial survey observations found, without exception, higher calf percentages than those based on comparable road surveys. Observations of caribou in non-riparian coastal portions of aerial surveys were eliminated from calf percentage estimates in order to eliminate possible bias associated with oversampling coastal areas (these areas generally support more cows and calves). A consequence of this deletion was an oversampling of riparian habitat within 1 km of the road system.

In summary, the seasonal changes of the herd along the road system reflected the north-south seasonal movements. Most of the caribou crossings of the road and/or pipeline were bulls, while calves comprised 3% of the caribou in crossing groups. The majority of crossings occurred near the coast and in general by larger groups than other areas. During the summer of 1977-1979 and the spring of 1977-1982, comparisons of calf percentages suggested that cow-calf groups were avoiding the corridor. However, no consistent differences were found during the fall to suggest any avoidance of the corridor. The authors concluded that parturient and maternal cows were sensitive to the human activities in developed areas on the Arctic Slope.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report is relevant to the determination of the validity of Hypothesis 2. The hypothesis states that increased traffic will decrease the number of caribou and alter their distribution. This study revealed consistent trends through the years but does not include data from pre-disturbance periods. Although the study concluded that there was avoidance of the corridor by cow-calf groups, these groups may have avoided the area previous to construction especially during the summer months.

MEMP PROJECT OVERVIEW NO. 2-16

TITLE: The buffalo of the North: caribou (*Rangifer tarandus*) and human developments.

PRINCIPAL INVESTIGATORS: A.T. Bergerud, R.D. Jakimchuk and D.R. Carruthers

AFFILIATION: University of Victoria and Renewable Resources Consulting Services Ltd.

FUNDING SOURCE: U. Vic.

COMPLETION DATE: 1984

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

This paper reviewed and assessed the impacts of human disturbance on the demography, movement and behaviour patterns of eight caribou populations. Five of these herds have been studied by the authors. The objective was to show how simple correlation reasoning of human disturbance effects on caribou obscures alternative explanations, and may lead to untestable generalizations and unsupportable conclusions. They stated that the major fallacy of this form of reasoning for cause and effect is that other possible causes may be occurring simultaneously with the supposed cause.

The authors concluded that behaviour patterns of caribou upon encountering transportation corridors could be explained in terms of adaptive responses to natural environment features. They found no evidence that disturbance activities or habitat alterations adversely affected productivity. Numbers of caribou have been affected by transportation corridors which allow easier access by hunters. No examples were found where physical features of corridors and associated disturbances had any effect on caribou productivity or numbers.

Review of the caribou populations revealed an apparent ability of caribou to adapt and a high resilience to human disturbance. The authors found that range limits and seasonal movements appear to be determined by changes in size of the population.

The authors concluded that transportation corridors must not be allowed to prevent caribou from crossing since a loss in usable space will eventually result in reduced numbers.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

To determine the validity of Hypothesis 2, information on the effects of human disturbance on caribou is required. This review is a major source of documentation of the interaction of caribou and human developments and should be considered when accepting or rejecting Hypothesis 2.

MEMP PROJECT OVERVIEW NO. 2-17

TITLE: Responses of caribou to ramps and pipelines in the west end of the Kuparuk Oilfield, Alaska, 1983.

PRINCIPAL INVESTIGATORS: S.M. Murphy and J.A. Curatolo

AFFILIATION: Alaska Biological Research

FUNDING SOURCE: Kuparuk River Unit Owners

COMPLETION DATE: 1984

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

The major objective of this study was to examine the effectiveness of ramps as a mitigation measure to facilitate caribou crossings of a pipeline and road. Data collected during the summer of 1983 involved the Central Arctic herd and included group size, group composition, route, times of entry and exit from the study area, insects, weather and traffic conditions and activity patterns.

Since caribou spent most of the summer near the coast because of insect conditions, caribou were observed in the study area during only half of the field days, and 82% of those observed were seen on three days. This resulted in a relatively small sample size on which to conduct statistical analyses. Caribou groups harassed by mosquitos moved significantly faster than those during insect-free periods. Movement patterns of caribou in 1983 were predominantly east or west and did not cross the pipeline and road. The rate of traffic averaged one vehicle every 1.3 minutes and one vehicle every 2.4 minutes after July 7, when traffic restrictions were imposed. Traffic appeared to significantly affect the crossing frequency of the pipeline by caribou. The authors reported that when caribou were harassed by mosquitoes they did not successfully cross the pipeline and road although caribou generally have an intense drive for movement to the coast for insect relief. In a 1982 study conducted in the area, when mosquitoes were present, crossing frequency increased.

The authors concluded that the difference between the two years reflected the construction of the Kuparuk Pipeline and an increase in traffic. Also, the high levels of traffic was the most significant factor affecting crossing frequency and success. In the presence of oestrid flies, crossing frequencies were higher in 1983 than 1982. Their data was reported to be consistent with other studies that also showed greater use of pipeline corridors by caribou during fly season. Most of the pipeline/road crossing occurred when oestrid flies were present.

Of the groups that successfully crossed the pipeline and road, 31% used the ramps as crossing sites, but all of the ramp crossings were completed when there were no insects. The authors concluded that ramps were not successful in maintaining pre-pipeline crossing frequencies due to poor design and high traffic levels.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The relevance of this study to Hypothesis 2 (effects of increased traffic on caribou movements and distribution) is that the conclusions deal with heavy traffic and insect harassment, which can be related to Links 1, 2, 6, 7, 8, and 9 of the hypothesis.

MEMP PROJECT OVERVIEW NO. 2-18

TITLE:	Caribou use of ramps for crossing pipe/road complexes, Kuparuk Oilfield, Alaska, 1984.
PRINCIPAL INVESTIGATOR:	S.M. Murphy
AFFILIATION:	Alaska Biological Research
FUNDING SOURCE:	Kuparuk River Unit Owners
COMPLETION DATE:	1984
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

The evaluation of effectiveness of the ramps in the 1983 study (see MEMP Project Overview No. 2-17) was continued in this study and the evaluation of an additional ramp was included. The study area was enlarged to encompass the added ramp site and to allow for a larger sample size. Many of the results were compared to 1983 and 1982 (see MEMP Project Overview No. 2-17). Insect conditions in July 1984 were similar to other years and again a large percentage of the observations were made in a small number of days (87% in 4 days). Comparisons of caribou movements in the presence of: a) mosquitos; b) oestrid flies; c) both species; or d) in the absence of insects, found that only when there were no insects was the direction of caribou movement significantly different from other insect conditions. Maps of group movements for 1984, 1983 and 1982 showed the movements of caribou were predictable under the influence of insects. Crossing frequencies (group and individual) in 1984 were significantly greater than those recorded in 1983 and were similar to those of 1982 (prior to Kuparuk Pipeline construction) despite an elevation in traffic levels on Spine Road. The author theorized that although the frequency of traffic was greater, the intensity of disturbance may have been reduced due to the decrease in large noisy vehicles (the increase in traffic was mainly due to small vehicles). He concluded that probable reasons for this increase were that in 1984 there were more small groups (these groups may have less trouble crossing than large groups), different traffic patterns, the larger study area in 1984 may have resulted in an artificial increase in crossing frequency and the caribou may have habituated to linear structures.

Crossing frequencies of two secondary pipeline/road complexes were significantly higher than the Kuparuk Pipeline/Spine Road complex. The author concluded this was due to the reduced volume of traffic on these roads. There was also a significant increase in the use of the Spine Road ramps for crossing in 1984 compared to 1983, but this did not include an increase in the number of large groups that used the ramps. Results of analyses comparing crossing frequencies in sections with or without ramps were inconclusive.

The most common form of disturbance to the caribou was found to be vehicle traffic. Over 50% of the crossings of elevated pipeline and roads were accompanied by moderate or severe reactions to the traffic. Fewer than 10% of those crossing by ramps had moderate or severe reactions.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of the study were applicable to the testing of Hypothesis 2 which states that increased traffic will decrease the number of caribou and alter their distribution. This study reveals the validity of the linkages that deal with the disruption of movement caused by increased traffic. However, note that traffic levels were intensive and that an above-ground oil pipeline was present adjacent to the roads. Thus, the results of the study may not be directly applicable to MEMP.

MEMP PROJECT OVERVIEW NO. 2-19

TITLE: Caribou movements along the Oliktok Road and in the Kalubik Creek region, Kuparuk Oilfield, Alaska, 1983.

PRINCIPAL INVESTIGATORS: M.A. Robus and J.A. Curatolo

AFFILIATION: Alaska Biological Research

FUNDING SOURCE: Kuparuk River Unit Owners

COMPLETION DATE: 1983

RELEVANT MEMP HYPOTHESIS: No. 2

BRIEF PROJECT DESCRIPTION

The objectives of the study were to determine the distribution and movements of the Central Arctic herd in two areas, along Oliktok Road to verify the continued use of crossing locations by caribou, and in the Kalubik Creek area to assist with the planning of caribou crossing facilities for proposed roads. The Oliktok Road crosses a major movement area for caribou during spring and summer.

Overall caribou movement patterns between Colville and Kuparuk rivers differed between the summers of 1983 and 1982 (see MEMP Project Overview No. 2-17). This difference was determined to be related to fluctuations in the abundance of mosquitos. Greater fluctuations between high and low levels of mosquitos in 1982 resulted in large number of north and south movements. Levels of mosquitos were high enough in 1983 to keep the caribou near the coast. In 1982, large numbers of caribou crossed Oliktok Road at several segments at the northern and southern ends. During 1983, caribou tended to cross midway along the road as a result of travel in a more east-west direction. The study found that caribou consistently crossed the Oliktok Road at several locations both when mosquitos were present and absent.

Recommendations regarding placement and design of the pipelines along Oliktok Road were given.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is relevant to Linkages 1 and 2 of Hypothesis 2. Link 1 refers to the barrier effects of the proposed road on the ability of the Porcupine caribou herd to reach insect-relief areas. Link 2 suggests that restricted access to insect-relief areas will increase the daily energy requirement, reduce fall fat storage and may increase the incidence of parasites. This study can be used to determine the validity of these statements.

MEMP PROJECT OVERVIEW NO. 2-20

TITLE:	Movements and activity budgets of caribou near oil drilling sites in the Sagavanirktok River floodplains, Alaska.
PRINCIPAL INVESTIGATOR:	S.G. Fancy
AFFILIATION:	LGL Alaska Research Associates
FUNDING SOURCE:	SOHIO
COMPLETION DATE:	1983
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

Movements and activity patterns of the Central Arctic caribou herd were compared between two active drilling sites on the periphery of Prudhoe Bay oilfield and a control site during July and August 1981. Along with the proportion of time spent in each activity (feeding, lying, walking, standing, running) and rate of movement, levels of insect harassment were also determined. The proportion of time spent feeding and lying was used as an indicator of disturbance due to drilling operations. Proportions of calves were also used as an indicator due to the influence of calves on group movement and activity. Vehicle traffic effects were compared between the drilling site and control site grids.

No statistical difference was found between the rate of movement between the drill site grids and control grids during either low or high levels of insects. Groups harassed by insects on both grids moved significantly faster (approximately twice as fast) than unharassed groups. The predominant direction of caribou movements (northeast) resulted in most caribou crossing the drill site grid and the control grid.

Insect harassment had a significant effect on the proportion of time spent in different activities on both study grids. But there was no statistical difference between the proportion of time spent lying and feeding (an indication of energy expenditure) on the study grids during low and high levels of insect harassment. Data suggested that during insect harassment and/or heat stress caribou sought out the drilling structures.

Crossing success of a road, pipeline or drill pad in the drill site grid was determined by combining movement data of 99 caribou groups from all directions of approach. Data showed that 70.7% of the groups crossed, 19.2% detoured around one of the drill sites and 10.1% reversed direction and left the grid.

In 1981, percentage of calves was lower on the control and drill site grids than for an estimate for a larger area of the herd's range, but in 1980 the two estimates were similar. However, in July 1980 the rate of traffic was almost twice that in 1981 and the amount of disturbance (noise, human activity and construction) was also much greater. The study concluded that there was no evidence that cows and calves were avoiding the area due to drilling operations.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 2 discusses the effects of traffic on the distribution and movement of the Porcupine caribou herd. The above study is relevant to testing the validity of this hypothesis. Rates of movements and activity were similar on both the test and control site grids. Insect harassment seemed to have the greatest effect on the caribou.

MEMP PROJECT OVERVIEW NO. 2-21

TITLE:	Caribou responses to the pipeline/road complex in the Kuparuk Oil Field, Alaska, 1981.
PRINCIPAL INVESTIGATORS:	J.A. Curatolo, S.M. Murphy and M.A. Robus
AFFILIATION:	Alaska Biological Research
FUNDING SOURCE:	ARCO Alaska, Inc.
COMPLETION DATE:	1982
RELEVANT MEMP HYPOTHESIS:	No. 2

BRIEF PROJECT DESCRIPTION

One of the major objectives of this study was to determine the effects of the pipeline/road complex on Central Arctic caribou herd movements, especially crossing success and travel routes. Four study sites were selected, two control sites, one site with road and pipeline separated, and one site with pipeline alongside the road. Recorded data were divided into two groups, mosquito season and oestrid fly season, and then were analysed statistically. Fieldwork was carried out in the summer of 1981.

The authors concluded that there was more reaction by caribou to a pipeline accompanied by a road with vehicles than to a pipeline alone. Also, crossing frequency for all group types and group sizes was less for the pipe/-road complex. Result of the study found that during mosquito season, caribou responded to a greater extent than during oestrid season. Caribou were found to select pipeline sections where the height exceeded 3.3 m but the authors stated that this may have been due to caribou following the adjacent topography.

During the study there were repeated and multiple crossings of the pipeline especially during the oestrid fly season. Rates of caribou movement for the pipeline/road complex and the pipeline were found to be greater than the control sites. Traffic on the roads affected the behaviour of the caribou. When roads without traffic were crossed there was no discernible reaction. However, when roads with traffic were crossed, all the crossing caribou showed some reaction. The authors concluded that the stimulus of moving vehicles alongside a raised pipeline created sufficient disturbance to evoke avoidance behaviour.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 2 states that increased traffic will decrease caribou numbers and alter their distribution. The above study is relevant when assessing the validity of this hypothesis.

HYPOTHESIS NO. 3

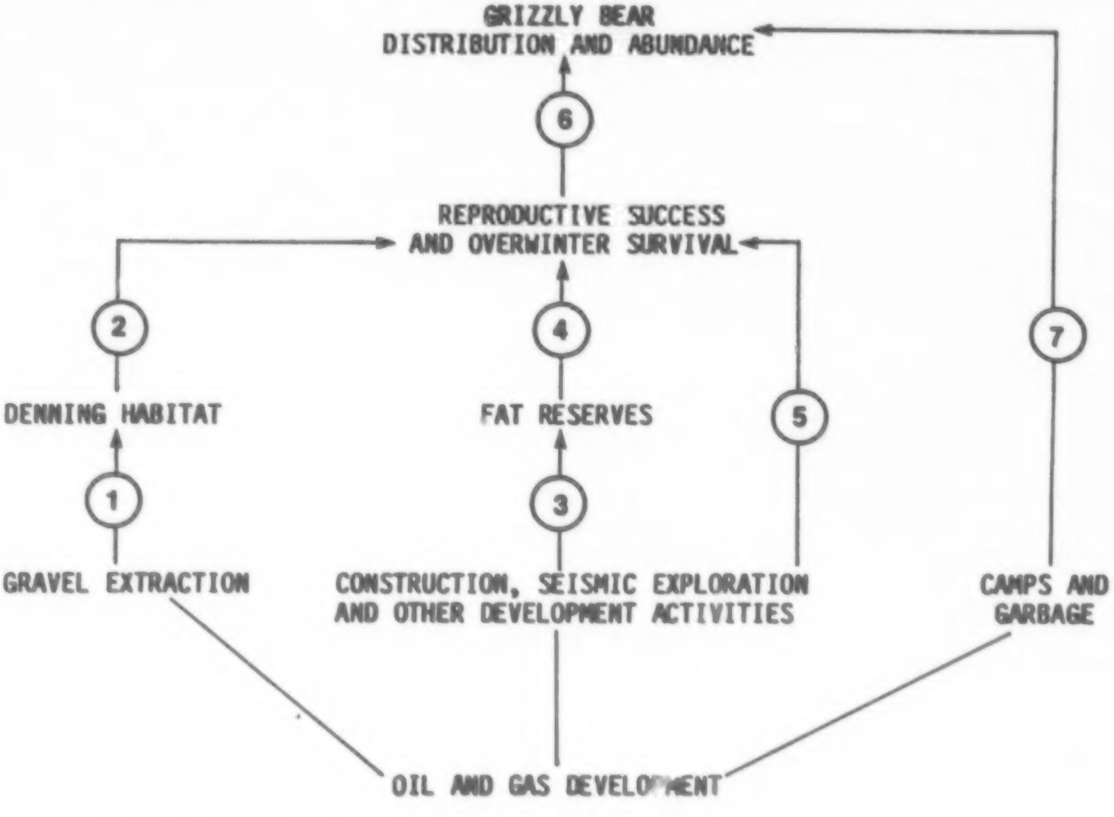
GRAVEL EXTRACTION, CONSTRUCTION, SEISMIC EXPLORATION AND OTHER DEVELOPMENT ACTIVITIES, AND THE PRESENCE OF CAMPS AND GARBAGE WILL DECREASE THE NUMBER OF GRIZZLY BEARS AND ALTER THEIR DISTRIBUTION

For Hypothesis No. 3, the valued ecosystem component was grizzly bear. Conclusions reached were that this hypothesis was valid. It was recommended that mitigative techniques be employed and that grizzly bear kills be recorded.

The following material covers four project overviews relevant to this hypothesis.

HYPOTHESIS NO. 3

Gravel extraction, construction, seismic exploration and other development activities, and the presence of camps and garbage will decrease the number of grizzly bears and alter their distribution


GRIZZLY BEAR
DISTRIBUTION AND ABUNDANCE
6
REPRODUCTIVE SUCCESS
AND OVERWINTER SURVIVAL
2
4
7
DENNING HABITAT
FAT RESERVES
5
1
3
GRAVEL EXTRACTION
CONSTRUCTION, SEISMIC EXPLORATION
AND OTHER DEVELOPMENT ACTIVITIES
CAMPS AND
GARBAGE
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Gravel extraction will remove denning habitat.

Link 2: A decrease in denning habitat will result in a decrease in reproductive success and overwinter survival.

Link 3: Construction and other development activities during late summer may disrupt feeding activity and increase movement of bears, which will result in decreased fat reserves in the fall.

Link 4: Fat reserves determine reproductive success, overwinter survival and quality of the fur.

Link 5: Construction, seismic exploration and other development activities during winter may cause bears to abandon their dens, which will reduce overwinter survival and reproductive success.

Link 6: Reproductive success and overwinter survival determine, in part, the size of the grizzly bear population.

Link 7: Grizzly bears that are attracted to camps and garbage may be destroyed as nuisance animals, which will result in a decrease in the grizzly bear population.

MEMP PROJECT OVERVIEW NO. 3-1

TITLE:	A review of northern grizzly bear ecology and habitat mapping techniques.
PRINCIPAL INVESTIGATORS:	W.G. Johnston, J.A. Stanforth and C.A. McEwan
AFFILIATION:	Northern Biomes, Whitehorse
FUNDING SOURCE:	Yukon Department of Renewable Resources
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 3

BRIEF PROJECT DESCRIPTION

Grizzly bear population dynamics for different study areas are reviewed relative to habitat quality. Grizzly bear population productivity is lower in northern grizzly bear range than in more southern ranges and differences occur in productivity between northern populations. The availability of high protein animal food may be a key factor affecting population productivity.

The limited number of grizzly bear habitat studies conducted in N.W.T., Yukon and Alaska have focused on specific ecological requirements such as denning, feeding and nursing habits or more general aspects of habitat use. No studies successfully mapped any aspects of grizzly bear habitat.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This is a review document which includes no new information. Studies conducted by grizzly bear researchers were synthesized; this synthesis relates to Links 1, 2, 4 and 6 of Hypothesis 3.

MEMP PROJECT OVERVIEW NO. 3-2

TITLE:	Grizzly bear conservation and management: a review.
PRINCIPAL INVESTIGATORS:	J.M. Peek, M.R. Pelton, J.D. Picton, J.W. Schoen and P. Zagar
AFFILIATION:	University of Idaho, University of Tennessee, Montana State University, Alaska Department of Fish and Game, Idaho Department of Fish and Game
FUNDING SOURCE:	Wildlife Society Inc.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 3

BRIEF PROJECT DESCRIPTION

This paper presents a review of the biology and human relations of grizzly bears in North America. It briefly summarizes grizzly bear status in North America, sources of mortality and various bear management problems.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This paper is related to Hypothesis 3, Link 7. The conclusion of this paper is that encroachment of humans into grizzly bear habitat results in increased bear/human conflict unless enlightened ethics that lead to better human understanding and tolerance occur. Link 7, which states that some grizzly bears will be destroyed as nuisance animals, remains true.

MEMP PROJECT OVERVIEW NO. 3-3

TITLE: Monitoring grizzly bear population trends.

PRINCIPAL INVESTIGATORS: L.L. Eberhardt, R.R. Knight and B.M. Blanchard

AFFILIATION: Batelle Memorial Institute and Montana State University

FUNDING SOURCE: U.S. National Park Service; U.S. Fish and Wildlife Service; U.S. Forest Service; Wyoming, Montana and Idaho Fish and Game Departments.

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 3

BRIEF PROJECT DESCRIPTION

A simple difference equation model was developed to provide an additional perspective on observed mortality and trend data on Yellowstone grizzly bears. Records of mortalities of adult females from 1959 to 1985 were utilized, in conjunction with data on females with cubs. The overall downward trend of observed numbers of females with cubs generally agrees with the model calculations, but does not adequately reflect mortality from 1970 to 1974. The model may be useful in developing a composite index of population trends.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Link 6 of Hypothesis 3 which states that "reproductive success and overwinter survival determines, in part, the size of the grizzly bear population." The model produced by this study approximates the effect of the observed mortality pattern on the population trend. It also takes into account litter sizes. This research supports the premise of Link 6 that the population size is primarily a function of mortality and reproductive success.

MEMP PROJECT OVERVIEW NO. 3-4

TITLE: Industrial effects on grizzly bear denning and habitat use on Richards Island.

PRINCIPAL INVESTIGATOR: P. Clarkson

AFFILIATION: N.W.T. Department of Renewable Resources

FUNDING SOURCE: NOGAP

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 3

BRIEF PROJECT DESCRIPTION

Grizzly bears on Richards Island were radio-collared and monitored in relation to industrial development activities in the area. Denning habitat and den emergence were assessed, habitat use was evaluated, and industrial-related mortality was documented. Results are currently being analysed.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 3, Links 1, 2, 5, 6, and 7. Results of the study are not yet available.

HYPOTHESIS NO. 4

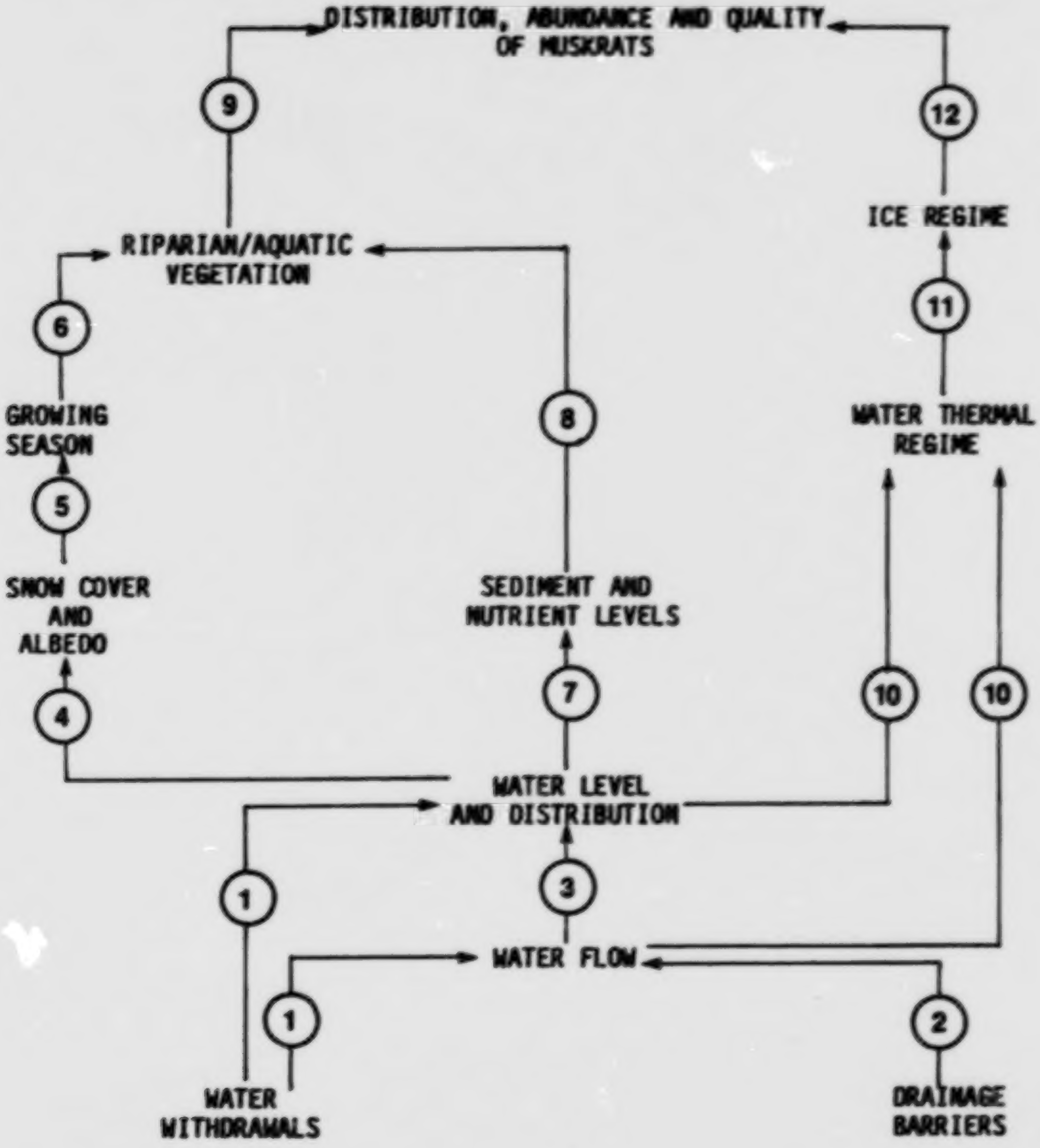
OIL AND GAS DEVELOPMENT ACTIVITIES WILL ALTER THE WATER REGIME AND DECREASE MUSKRAT POPULATIONS

For Hypothesis No. 4, the valued ecosystem components was muskrat. Conclusions reached were that this hypothesis was invalid and not worth testing, and no specific studies were required.

However, the following material covers eight project overviews relevant to this hypothesis.

HYPOTHESIS NO. 4

Oil and gas development activities will alter the water regime and decrease muskrat populations


DISTRIBUTION, ABUNDANCE AND QUALITY OF MUSKRATS
9
12
ICE REGIME
11
RIPARIAN/AQUATIC VEGETATION
6
GROWING SEASON
5
SNOW COVER AND ALBEDO
4
8
SEDIMENT AND NUTRIENT LEVELS
7
WATER THERMAL REGIME
10
10
WATER LEVEL AND DISTRIBUTION
1
3
WATER FLOW
1
2
WATER WITHDRAWALS
DRAINAGE BARRIERS

LINKAGES

Link 1: Water withdrawals will decrease water flow in smaller streams and water levels in smaller lakes.

Link 2: Physical drainage barriers across the mackenzie Delta will interrupt the pattern of water flow.

Link 3: Patterns of water flow determine water levels and distribution.

Link 4: The timing and extent of overbank flooding determine the duration of snow cover and the albedo.

Link 5: The duration of snow cover and albedo influence the length of the growing season.

Link 6: The length of the growing season influences the growth and species composition of riparian and aquatic vegetation.

Link 7: The timing and extent of overbank flooding affect the levels and distribution of nutrients and sediments.

Link 8: The levels and distribution of nutrients and sediments influence the growth and species composition of riparian and aquatic vegetation.

Link 9: The growth and species composition of riparian and aquatic vegetation affect the population size and quality of muskrats through influences on feeding and survival.

Link 10: Changes in water flow and water level affect the water thermal regime.

Link 11: The water thermal regime affects the ice regime.

Link 12: The ice regime affects survival of muskrats.

MEMP PROJECT OVERVIEW NO. 4-1

TITLE:	The effect of water level fluctuations on muskrat (*Ondatra aibethicus*) predation by mink (*Mustela vison*).
PRINCIPAL INVESTIGATORS:	G. Proulx, J.A. McDonnell, and F.F. Gilbert
AFFILIATION:	Alberta Environmental Centre, Ontario Ministry of Natural Resources, and Washington State University
FUNDING SOURCE:	AEC, OMNR and Wash. State U.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 4

BRIEF PROJECT DESCRIPTION

A study of mink food habits and movements was undertaken incidental to studies on muskrats at Luther Marsh, Ontario, 1978-1980. In the summers of 1978 and 1979, when the water level was low, mink went deep into the marsh and preyed on aquatic birds and muskrats. In 1980, with high water levels, mink movements appeared to be restricted to the marshland edge and they preyed mostly on crayfish and meadow voles. The 1979-80 winter scat analysis indicated that muskrats were the major mink food item in frequency and volume.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This paper relates to Hypothesis 4 and indicates that changing water levels may affect muskrats through physical (i.e., Links 1, 3, 10) and biological events. The increase in predation on muskrats during low water level periods has not been considered in Hypothesis 4. However, the validity of the entire hypotheses was rejected based on the lack of support for the first two links upon which all others were based.

MEMP PROJECT OVERVIEW NO. 4-2

TITLE:	Quantitative synthesis of the Mackenzie Delta ecosystem.
PRINCIPAL INVESTIGATORS:	S. Hirst, M. Miles, S.P. Blachut, L.A. Goulet and R.E. Taylor
AFFILIATION:	Applied Ecology Ltd.
FUNDING SOURCE:	Inland Waters Directorate and Indian and Northern Affairs Canada
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No.'s 4, 7, 10, 11, 14 and 16

BRIEF PROJECT DESCRIPTION

Muskrats are year-round residents of the delta and their habitat determinants relate mainly to feeding and denning. Summer food resources are abundant since muskrats are catholic in their feeding preferences. Submerged macrophytes are an essential winter food resource and can only be utilized if lake ice cover thickness and free water below the ice permit construction of plunge-holes and pushups. These factors restrict pushup construction in the winter. The degree of closure (isolation) and distance from channels significantly affect lake depths and the amount of free water available; these are greatest in high closure lakes and lowest in some connected and low closure lakes.

Muskrat denning determinants include stable water levels, adequate bank slopes and stability, heterogeneity in bank conditions, and an absence of strong currents. The preferred combination of factors are gently sloping banks with stable water levels and variable vegetation cover from emergents to deciduous shrubs. Channels and connected lakes are generally avoided because of significantly greater water level fluctuations and lower frequency occurrence of macrophytes. Den sites are more numerous in levees and thermokarst banks around lakes with closure. Denning preferences are influenced by the local availability of sites; hence preferences vary significantly between regions in the delta. Maximum muskrat denning densities occur in the south-western delta.

Mackenzie Delta muskrats are highly localized and most are believed to remain localized within the same basin all their lives. Densities increase significantly each fall by a factor of 2-5 or greater due to reproductive increases, although declines from summer through fall occur in some basins. Dispersal of juveniles to adjacent basins occur in fall each year. Mean summer muskrat densities are significantly higher in the south-western delta (0.3-2.6 muskrats per 100 m basin shoreline. Corresponding densities were 0.6-2.2 in the west-central delta, 0.2-1.2 in the south-east, and 0-0.4 per 100 m shoreline in the outer delta. Fall densities (0-4.8 per 100 m shoreline) do not differ significantly between different areas, likely due to the high rates of compensatory population increase.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report relates to Hypothesis 4, Links 3, 9 and 12. However, because the entire hypothesis was considered to be invalid on the basis of the first two links related to water withdrawals and physical drainage barrier, the validity of Links 3-12 is inconsequential.

This report also relates to Hypothesis 11, Links 3 and 6 which concern habitat quality. Distribution and abundance of muskrats were related to various features of habitat, including water depths, water-level fluctuations and bank conditions. Although it was cautiously concluded that land subsidence due to reservoir depletion would have inconsequential affects on muskrat populations, the working group conceded that there was potential for impact if extensive areas were affected by induced subsidence.

MEMP PROJECT OVERVIEW NO. 4-3

TITLE:	Lake regimes, Mackenzie Delta, N.W.T., 1982, 1983 and 1984.
PRINCIPAL INVESTIGATORS:	S.G. Bigras
AFFILIATION:	Environment Canada, National Hydrology Research Institute
FUNDING SOURCE:	Environment Canada
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 4

BRIEF PROJECT DESCRIPTION

These reports, which expand upon previous studies undertaken by Bigras (1985) and Marsh (1985) discuss aspects of the April to September water balance of 3 areas located on the eastern side of the Mackenzie Delta. The study areas encompass a range of levee heights and vegetation characteristics. Data are presented on: 1) the importance of backwater flooding from ice jams; 2) the processes of lake inflow, outflow and evaporation; 3) hydrometeorological conditions; and 4) physiographic controls. The study indicates that the spring freshet provides an inflow of water to connected and closure type lakes in the mid- and outer Delta. In contrast, backwater flooding due to ice jams was required to provide water to high perched lakes in the southern delta.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

These reports provide data on the relative contributions of surface flow, snow melt and precipitation to the water balance of seasonally isolated lakes. This information is relevant to Hypothesis 4 as it would allow the calculation of the effect of water withdrawals on the water balance of isolated lakes and small streams.

MEMP PROJECT OVERVIEW NO. 4-4

TITLE: Mackenzie Delta environmental hydrology.

PRINCIPAL INVESTIGATORS: S. Blachut, R.E. Taylor and S.M. Hirst

AFFILIATION: B.C. Hydro and Power Authority

FUNDING SOURCE: B.C. Hydro and Power Authority

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No.'s 4 and 11

BRIEF PROJECT DESCRIPTION

This report presents the results of the hydrological studies conducted by B.C. Hydro and Power Authority in the Mackenzie Delta. Water level measurements undertaken in the period between 1981 and 1983 are summarized. The extent of overbank spring freshet flooding was documented through the use of aerial photography. These data were used to quantify the flooding characteristics of various terrain units.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The report provides quantitative data on the water level, flooding frequency and flooding duration characteristics of various landforms occurring in the Mackenzie Delta. These data provide a basis for assessing how water withdrawals might affect riparian or aquatic vegetation. In addition, this information could be useful when evaluating how the flooding regime might be affected by induced subsidence.

MEMP PROJECT OVERVIEW NO. 4-5

TITLE: The distribution and ecology of the shoreline vegetation on the Mackenzie Delta, N.W.T.

PRINCIPAL INVESTIGATOR: C.M. Pearce

AFFILIATION: Department of Geography, University of Calgary, Alberta

FUNDING SOURCE: B.C. Hydro and Power Authority, University of Calgary

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No.'s 4 and 11

BRIEF PROJECT DESCRIPTION

This thesis investigates the distribution of shoreline vegetation on the Mackenzie Delta and for factors controlling plant colonization and succession on mudflat areas. The report, which was undertaken in conjunction with studies by Cordes and Associates (1979, 1984a-d, 1985) for the B.C. Hydro and Power Authority, greatly expands on earlier studies by Gill (1971, 1977, 1973a,b). The physical and hydrological characteristics occurring at study sites encompassing the entire range of vegetation types and sub-types which occur on the Mackenzie Delta are quantified. Important parameters identified include the timing and magnitude of the annual spring flood, water level fluctuations over the growing season, and the amount and texture of alluvium deposited during flooding. Other identified parameters include active layer thickness, temperature and precipitation over the growing season, competition from other plants and grazing by waterfowl and muskrats.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The report provides a basis for quantifying the relationship between physical or hydrological characteristics and the resulting vegetation communities. Such data may allow informed speculation on how land subsidence or changes in water level could affect plant communities.

MEMP PROJECT OVERVIEW NO. 4-6

TITLE:	Quantitative synthesis of the Mackenzie Delta ecosystem.
PRINCIPAL INVESTIGATORS:	S. Hirst, M. Miles, S. Blachut, L. Goulet and B. Taylor
AFFILIATION:	Applied Ecology Consultants Ltd.
FUNDING SOURCE:	INAC and IWD, B.C. Hydro and Power Authority
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 4, 11 and 16

BRIEF PROJECT DESCRIPTION

This report attempts to synthesize all environmental data collected on the Mackenzie Delta by the B.C. Hydro and Power Authority as well as most other relevant data. Information is presented on the physical and biological characteristics of the study sites representative of the range in conditions that occur on the Mackenzie Delta.

The objective of these studies is to provide a quantitative basis for describing the relationship between physical characteristics and the resulting aquatic and terrestrial plant and animal communities. As an example of the use of such data, a numerical model was developed to simulate lake productivity. An extensive analysis of changes in climatic and discharge regimes in the Mackenzie River watershed was also undertaken.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report provides data which can, in some cases, be used to quantify the linkages identified above. Nevertheless, the study results indicate that there are large spatial and temporal variations in both physical and biological processes occurring on the Mackenzie Delta. This variation, plus the complexities of the processes involved, indicate that quantifying the type of flow charts presented in MEMP 1985-1986 would require a substantial sampling effort.

MEMP PROJECT OVERVIEW NO. 4-7

TITLE:	Muskrat push-up surveys in the Mackenzie Delta-May 1981 and 1982.
PRINCIPAL INVESTIGATOR:	L.A. Goulet
AFFILIATION:	B.C. Hydro and Power Authority
FUNDING SOURCE:	B.C. Hydro and Power Authority
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 4

BRIEF PROJECT DESCRIPTION

In May 1981, muskrat push-ups were surveyed from the air in the Mackenzie Delta on 170 lakes in six study areas. In May 1982, 158 lakes in the same six study areas and 113 lakes on two transects across the delta were also surveyed for muskrat push-ups. Ground surveys were conducted on 37 lakes in May 1982 to measure levee, shrub and tree heights, snow depth, ice thickness, lake depth and push-up activity. Three lake types were compared (i.e., connected lakes and lakes with low and high closure).

Mean levee height above lake ice decrease from south (2.8 m) to north (0.5 m), and from connected lakes (3.3 m) to low closure (2.3 m) to high closure (1.8 m) lakes. Average snow depth appeared to be greater on connected lakes. Snow depth was greater in the southern portion of the delta and was greater on the eastern than on the western side of the delta. Mean ice thickness on lakes increased from south (74 cm) to north (172+ cm) in the delta, likely a result of decreasing snow depth and increasingly rigorous climatic conditions. Mean ice thickness was also greater in the western delta (an area of lesser snow depth) than in the eastern delta.

Push-up density per se is of little value to compare muskrat populations between years or study areas as varying snow depths change push-up detectability. However, there were indications that connected lakes may be less productive than non-connected lakes. No active push-ups were found on lakes with ice-free water depth less than 25 cm or with ice thickness exceeding 1.7 m.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study related in part to Link 12 of Hypothesis 4, which states that "the ice regime affects survival of muskrats". Goulet found no active push-ups with ice thickness of more than 1.7 m. She also related ice thickness to snow depth.

MEMP PROJECT OVERVIEW NO. 4-8

TITLE:	The distribution and ecology of the shoreline vegetation on the Mackenzie Delta, N.W.T.
PRINCIPAL INVESTIGATOR:	C.M. Pearce
AFFILIATION:	Department of Geography, University of Calgary
FUNDING SOURCE:	University of Calgary
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 4

BRIEF PROJECT DESCRIPTION

This thesis analysed the distribution of the shoreline vegetation on the Mackenzie Delta and the dynamics of plant colonization and early succession on mudflats. The shoreline vegetation was described within a system of ecological land classification which related the distribution of plant association to macroclimate and the fluvial regime. The distribution of vegetation on shorelines of channels and lakes was closely related to flooding, sedimentation and erosion. Of particular importance were the timing and magnitude of the annual spring flood, water level fluctuations over the growing season, and the amount and texture of alluvion deposited during flooding. Also important were temperatures and precipitation over the growing season, competition from other plants and grazing by waterfowl and muskrats.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Links 7 and 8 of Hypothesis 4 which states that the timing and extent of overbank flooding affects the levels and distribution of nutrients and sediments which in turn influence the growth and species of riparian and aquatic vegetation. This thesis reconfirms these two links and briefly considers information supporting Link 6 which states that "the length of the growing season influences the growth and species composition of riparian and aquatic vegetation." The influence of competition by other plants and waterfowl has not been considered in the development of Hypothesis 4; however, because Links 1 and 2 of the hypothesis were considered invalid, no further links were discussed.

HYPOTHESIS NO. 5

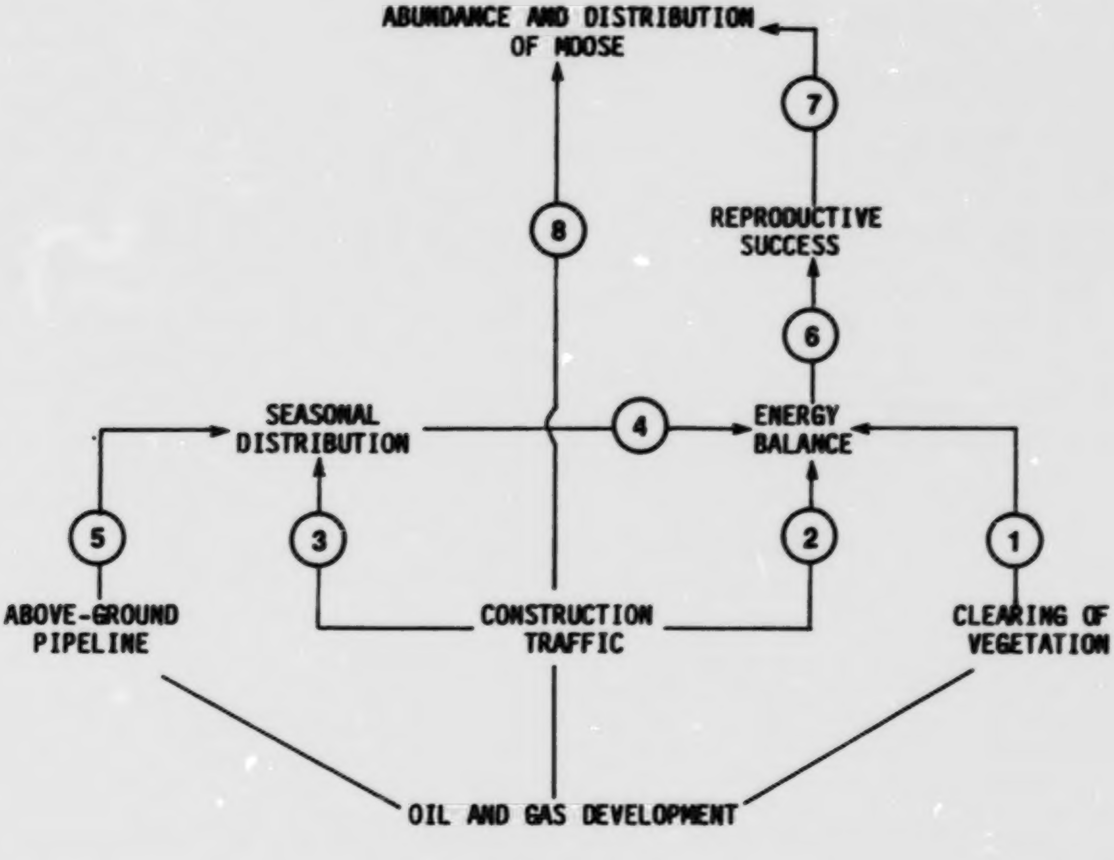
OIL AND GAS DEVELOPMENT CONSTRUCTION AND CLEARING ACTIVITIES AND THE PRESENCE OF AN ABOVE-GROUND PIPELINE WILL CHANGE THE ABUNDANCE AND DISTRIBUTION OF MOOSE

For Hypothesis No. 5, the valued ecosystem component was moose. Conclusions reached were that this hypothesis was unlikely to be valid. It was recommended that browse regeneration be monitored and moose kills recorded.

The following material covers eight project overviews relevant to this hypothesis.

HYPOTHESIS NO. 5

Oil and gas development construction and clearing activities and the presence of an above-ground pipeline will change the abundance and distribution of moose


ABUNDANCE AND DISTRIBUTION OF MOOSE
7
8
REPRODUCTIVE SUCCESS
6
SEASONAL DISTRIBUTION
4
ENERGY BALANCE
5
3
2
1
ABOVE-GROUND PIPELINE
CONSTRUCTION TRAFFIC
CLEARING OF VEGETATION
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Wood-chipping operations, seismic lines, right-of-way, and other clearing will increase the amount of food available to moose in the short to medium term.

Link 2: Construction activities and associated traffic will disturb and harass female moose and their young and cause individuals to expend more energy to locate suitable habitat.

Link 3: Construction activities and associated traffic will disturb moose populations and lead to a change in distribution and the location of some individuals in alternative habitat and areas.

Link 4: Changes in the seasonal distribution of moose will increase the amount of energy required for some individuals to locate suitable habitat.

Link 5: An above-ground pipeline will prevent the passage of moose, which will lead to changes in migration patterns.

Link 6: The energy balance of an adult determines its reproductive success.

Link 7: Reproductive success determines, in part, the number of moose in the population.

Link 8: Increased traffic associated with development will result in increased numbers of moose killed through collisions with vehicles.

MEMP PROJECT OVERVIEW NO. 5-1

TITLE: Oil pipeline crossing sites utilized in winter by moose (*Alces alces*) and caribou (*Rangifer tarandus*) in South Central Alaska.

PRINCIPAL INVESTIGATORS: S.H. Eide, S.D. Miller and M.A. Chihuly

AFFILIATION: Alaska Department of Fish and Game

FUNDING SOURCE: ADF&G

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No.'s 5 and 2

BRIEF PROJECT DESCRIPTION

Crossing sites selected by moose and barren-ground caribou were studied along a 145 km segment of the Trans-Alaska oil pipeline in south central Alaska during the first winter of pipeline operation. Physical characteristics of the pipe were recorded at locations where moose and caribou tracks were found in the snow on the pipeline pad. The characteristics of pipe design at these encounters were compared with the availability of these characteristics based on construction drawings. No consistent pattern of selection by moose was found for different vertical clearance heights of elevated pipe, for buried vs. elevated pipe, or for sites where the pipe was specially elevated or buried for short distances to facilitate crossings. Apparently, moose were not influenced in their selection of pipeline crossing sites by pipeline characteristics. They may have been influenced prior to reaching the pipeline pad, or may not yet have established preferred crossing sites. Caribou tended to select for elevated pipeline heights over 8 feet (2.4 m) and against those less than 7 feet (2.1 m). Caribou showed strong selection for long-buried sections of the pipeline that were intentionally located in areas where caribou migrations traditionally crossed the pipeline corridor. Caribou showed no selection for the short, specially-designed, crossing sites.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This paper relates to Hypothesis 5, Link 5 which states that "an above-ground pipeline will prevent the passage of moose, which will lead to changes in moose migration patterns." These new data refute earlier data regarding the height of raised pipelines for moose. Apparently, moose were not especially facilitated in crossing the pipeline by specially designed big-game crossing sites. A moose motivated to cross the pipeline would do so regardless of the physical characteristics of the pipeline. Moose populations appeared to be unaffected by the pipeline. Two populations whose range was bisected by the pipeline are at least as large and productive as they were prior to pipeline construction. Therefore, this paper does not support Link 5.

MEMP PROJECT OVERVIEW NO. 5-2

TITLE:	Seasonal foraging rates of free-ranging moose.
PRINCIPAL INVESTIGATORS:	L.A. Renecker and R.J. Hudson
AFFILIATION:	University of Alberta, Edmonton
FUNDING SOURCE:	U. of Alta.
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 5

BRIEF PROJECT DESCRIPTION

Foraging rates of free-ranging moose in aspen boreal habitats were evaluated in summer, autumn and winter. Consumption rates (g/min) increased asymptotically with biomass of potential forage, but both maximum rates and slopes varied seasonally. Maximum rates appeared related to forage quality since values declined from 23 g/min in July to 11 g/min in January. Slopes reflecting increments of foraging rate/unit increase in biomass seemed related to selectivity exercised by moose. The highest values were observed in winter when moose were least selective, the lowest in October when a mixture of green and cured forage offered the greatest opportunities for selective feeding.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 5, Link 1 which state that "clearing will increase the amount of food available to moose in the short to medium term". The results indicate the importance of quality as well as quantity of vegetation consumed by moose during winter. Link 1 placed the entire emphasis on quantity. As can be seen from this study, consumption rates of forage increased as forage quality improved.

MEMP PROJECT OVERVIEW NO. 5-3

TITLE:	Estimates of digestibility of birch, willow and aspen mixtures in moose.
PRINCIPAL INVESTIGATORS:	C.C. Schwartz, W.L. Regelin and A.W. Franzmann
AFFILIATION:	Alaska Department of Fish and Game and U.S. Fish and Wildlife Service
FUNDING SOURCE:	ADF&G and USFWS
COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 5

BRIEF PROJECT DESCRIPTION

Four feeding trials were conducted during winter with captive moose at the Moose Research Centre, Soldotna, Alaska. Objectives were to estimate intake and digestibility of: 1) a mixed diet of 70% paper birch, 20% aspen and 10% willow; 2) a mixed diet of 30% aspen and 70% pelleted ration; and 3) a mixed diet containing equal portions of paper birch, willow and aspen browse. Moose would not consume the mixed diet that contained 70% birch, and the trial was terminated after 1 week. Dry matter intake of the aspen and pelleted ration was 52.4 ± 12.5 (SD) g/kg body weight $(BW)^{0.75}$/day. The estimate of dry matter digestion (DMD) for aspen was 40.9 ± 8.5%. Dry matter intake and DMD for the mixed-browse diets ranged from 25.4 to 38.6 g/kg $BW^{0.75}$/day, and 31.1 to 38.6%, respectively. Digestible and metabolizable energy represented 37.0 and 27.8% of gross energy intake, respectively. Energy intake was below levels required for winter maintenance.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 5, Link 1 which state that "clearing will increase the amount of food available to moose in the short to medium term" The results indicate the importance of quality as well as quantity of vegetation consumed by moose during winter. Link 1 placed the entire emphasis on quantity. As can be seen from this study, a diet high in birch was almost totally rejected by moose.

MEMP PROJECT OVERVIEW NO. 5-4

TITLE: Winter activity patterns of moose in interior Alaska.

PRINCIPAL INVESTIGATOR: K.L. Risenhoover

AFFILIATION: Michigan Technological University

FUNDING SOURCE: Mich. Tech. Univ.

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 5

BRIEF PROJECT DESCRIPTION

Moose diel activity patterns were studied in Denali National Park and Preserve, Alaska, during the winter-spring period, 1983-84. Mean active time/24-hour day increased from 5.8 hours in early February to 7.8 hours by late April. Moose averaged 5-6 feeding periods/24 hours. Bedding periods averaged 178 minutes and feeding periods 68 minutes. Feeding and bedding periods alternated in a polyphasic pattern and were generally synchronized among individuals. Activities associated with resting and foraging constituted 99.3% of moose winter time budgets. Moose, on average, spent 66.9% of bedding periods ruminating and 76.2% of feeding periods harvesting and ingesting forage. Variations in daily activity levels were related to daily movements by moose. Distance travelled increased exponentially as the duration of foraging periods increased. Seasonal changes in levels of activity appear to reflect behavioural and physiological adaptations of moose to temporal changes in forage quality and patterns of forage distribution.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Link 4 of Hypothesis 5 which states that "changes in the seasonal distribution of moose will increase the amount of energy required for some individuals to locate suitable habitat." This study shows that additional energy is expended by moose as they search for suitable seasonal foraging habitat. Links 2 and 3 (relating to disturbance to moose) were considered invalid, and Link 4 was considered unlikely to occur. Therefore, additional data are needed on Links 2 and 3 before Link 4 can be accepted.

MEMP PROJECT OVERVIEW NO. 5-5

TITLE: Revegetation monitoring of the Interprovincial Pipeline (NW) Ltd., Norman Wells to Zama pipeline.

PRINCIPAL INVESTIGATOR: Hardy BBT Limited

AFFILIATION: Hardy BBT Limited

FUNDING SOURCE: Interprovincial Pipeline (NW) Ltd.

EXPECTED COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No.'s 5 and 6

BRIEF PROJECT DESCRIPTION

The objectives of this program are to assess the revegetation success and to monitor vegetation recovery over time. In order to determine the effect of seed and fertilizer on revegetation success and material recovery, trial sites were established (see MEMP Project Overview 5-8). Total plant cover during 1987 was similar to that present during 1986 and averaged 66% on sites seeded during 1984 and 55% on sites seeded during 1985. Living cover on the right-of-way seeded in 1984 declined to 27% in 1987 from 44% in 1986, likely due to a drier and warmer growing season and a reduced fertilizer effect.

Recovery of native vascular species was varied. On 1984 seeded right-of-way and slopes, native species cover averaged 9%, down from 13% in 1986, while on campsite and spoil sites native cover was 18%, double that in 1986. On 1985 seeded right-of-way, native vascular cover was 12%, similar to that in 1986, while on slopes, cover was 16%, a four-fold increase since 1986. Cover on the campsite seeded in 1985 was dominated by seeded species. Shrub and tree cover generally increased in 1987. On the right-of-way, cover of shrubs and trees was highest on the spoil side at 11% and 4%, respectively, on the sections seeded in 1985 and 1984, and lowest on the backfilled ditch at 2.5 and 1.7%, respectively.

Natural revegetation of organic terrain remained slow particularly on the deep organic deposits south of Fort Simpson. On shallower peat veneers elsewhere along the right-of-way native plant cover was similar to that on seeded and fertilized sites.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is relevant to Hypothesis 5, Link 1 and Hypothesis 6, Link 1 and Link 4, all of which consider the resulting vegetation component on seismic lines, wood-chip operations, temporary winter roads and pipeline right-of-ways. During 1987, shrub and tree cover averaged 3.7% and 6.3% on the right-of-ways seeded in 1984 and 1985, respectively. The species of trees and shrubs were related to the plant communities adjacent to the right-of-way. This low level of revegetation of browse does not support Hypothesis 5, Link 1 which states that clearings "will increase the amount of food available to moose in the short to medium term."

This study provides some support to Hypothesis 6, Links 1 and 4. The nature of the vegetation change has been documented on the right-of-way and can be related to the preferred breeding habitat of marten and the preferred habitats of the prey species of marten. This is strictly a vegetation study and does not consider wildlife habitat.

MEMP PROJECT OVERVIEW NO. 5-6

TITLE: Effects of winter seismic exploration on the coastal plain, Arctic National Wildlife Refuge, Alaska, 1984.

PRINCIPAL INVESTIGATORS: N.A. Felix and M.T. Jorgenson

AFFILIATION: U.S. Fish and Wildlife Service

FUNDING SOURCE: U.S. Department of Interior

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No.'s 5 and 6

BRIEF PROJECT DESCRIPTION

The impacts of the 1984 winter seismic exploration program upon the vegetation, thermal regime and visual resources of the Arctic Coastal Plain were measured. Short-term impacts of vehicle traffic were evaluated, and these data will be used as a basis for a long-term recovery study. Changes in vegetation and soils associated with various levels of disturbance were assessed on 16 intensive study plots (30 m x 4 m) and 52 photo trend plots (10 m x 4 m). Vegetation disturbance in wet lowland areas ranged from compression of standing dead and slight surface scuffing to compaction of the moss mat below the water surface. Disturbance in tussock tundra ranged from scuffing of tussocks and less than 25% decrease in vegetative cover to mound top destruction with ruts starting to form, over 50% decrease in vegetative cover and over 15% peat exposed. Disturbance in Dryas river terrace commonly included over 50% vegetation damage and over 15% soil exposed. Generally, soil exposure was limited to the surface of the organic layer. Thaw depth increases ($P<0.05$), ranging from 2.7 - 7.8 cm, occurred in 35% of the disturbed plots within all vegetation types. Track depression, due to a combination of compaction and thaw settlement, was evident at 1 plot in moist sedge, prostrate shrub tundra where the average track depression was 8.9 cm. The relationship between disturbance levels, vegetation types, traffic patterns, and snow cover was examined using interpretation of colour infrared aerial photographs. Higher level disturbances occurred more often in vegetation types with high micro-relief and those dominated by birch, dryas, and ericaceious shrubs than in wet lowland habitats. Camp-move vehicles (cat-trains) caused higher disturbance levels than seismic vehicles. Narrow, concentrated trails (both camp move and seismic) caused higher levels of disturbance than diffuse trails. Nodwell turns created more disturbance than straight Nodwell trails. A reliable understanding of the relationship between snow cover and disturbance caused by future winter seismic exploration include avoiding narrow, concentrated vehicle trails; routing vehicle traffic and locating campsites in less sensitive vegetation types and areas of high snow cover; and strict monitoring to prevent leaks and spills of oil, diesel and gasoline.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 5, Link 1 and Hypothesis 6, Link 1 and Link 4, all of which consider the resulting vegetation component on seismic lines. This study documents a general decline in total vegetative cover and soil disturbance from winter seismic activities in tundra areas. Because all of the links mentioned above expect enhanced vegetative diversity on seismic lines, this study invalidates these links for tundra areas.

MEMP PROJECT OVERVIEW NO. 5-7

TITLE:	Wildlife monitoring studies along the Norman Wells - Zama Oil Pipeline, November 1984 to May 1987.
PRINCIPAL INVESTIGATORS:	R. Eccles, J. Duncan, G. Searing, C. Thomson
AFFILIATION:	Delta Environmental Management Group Ltd. and LGL Limited
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 5 and 6

BRIEF PROJECT OVERVIEW

This was a 3-year monitoring program to assess the effects of pipeline construction and operation on the abundance, distribution and local movements of wildlife within the IPL pipeline corridor. The final report concluded that the construction and operation of the Norman Wells - Zama Oil Pipeline did not significantly alter the abundance, distribution or local movements of wildlife. Some displacement may have occurred during construction but did not persist. Habitat alterations were considered to have a negative impact for small furbearers and a positive impact on the habitat of large mammals.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 5, Link 3 which states that "construction activities and associated traffic will disturb moose populations and lead to a change in distributions and the location of some individuals in alternative habitat and areas". Although comparative pre-construction data were not available, data collected during this study suggested that moose avoided the area within 750 m of the right-of-way during pipeline construction.

This study also relates to Hypothesis 6. The lack of a significant effect on the distribution, abundance and local movements of marten supports the linkages of Hypothesis 6 which did not include displacement of marten by disturbance factors.

MEMP PROJECT OVERVIEW NO. 5-8

TITLE:	Long term evaluation of revegetation and restoration, Norman Wells Pipeline.
PRINCIPAL INVESTIGATOR:	K.L. MacInnes
AFFILIATION:	Indian and Northern Affairs Canada
FUNDING SOURCE:	INAC, Energy, Mines and Resources and Interprovincial Pipeline (NW) Ltd.
EXPECTED COMPLETION DATE:	In Progress
RELEVANT MEMP HYPOTHESIS:	No.'s 5 and 6

BRIEF PROJECT DESCRIPTION

The objectives of this project are:

1. to determine the long-term modifications to the composition, cover, productivity and active layer of the alignment area resulting from pipeline development and revegetation/restoration practices;
2. to assess the long-term effects of types of assisted revegetation on rates of reinvasion by native plant species and regrowth of existing vegetation;
3. to examine other selected ecological interactions or effects of pipeline revegetation/restoration;
4. to compare actual and predicted impacts; and
5. to evaluate the long-term effectiveness and benefits of revegetation-restoration procedures and identify improvements which may be made in future northern pipelines or similar development activities.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This project relates to Hypothesis 5, Link 1 which states that "wood chipping operations, seismic lines, right-of-ways and other clearing will increase the amount of food available to moose in the short to medium term." This study will monitor the regeneration of browse and other plants related to various revegetation strategies and the original floristic composition.

This study also relates to Hypothesis 6, Link 4 which states "seismic lines, wood-chip operations, temporary winter roads and pipeline right-of-ways will temporarily increase marten feeding habitat." The degree to which vegetation changes occur will be documented and can be related to habitat preferences of the prey species of marten.

HYPOTHESIS NO. 6

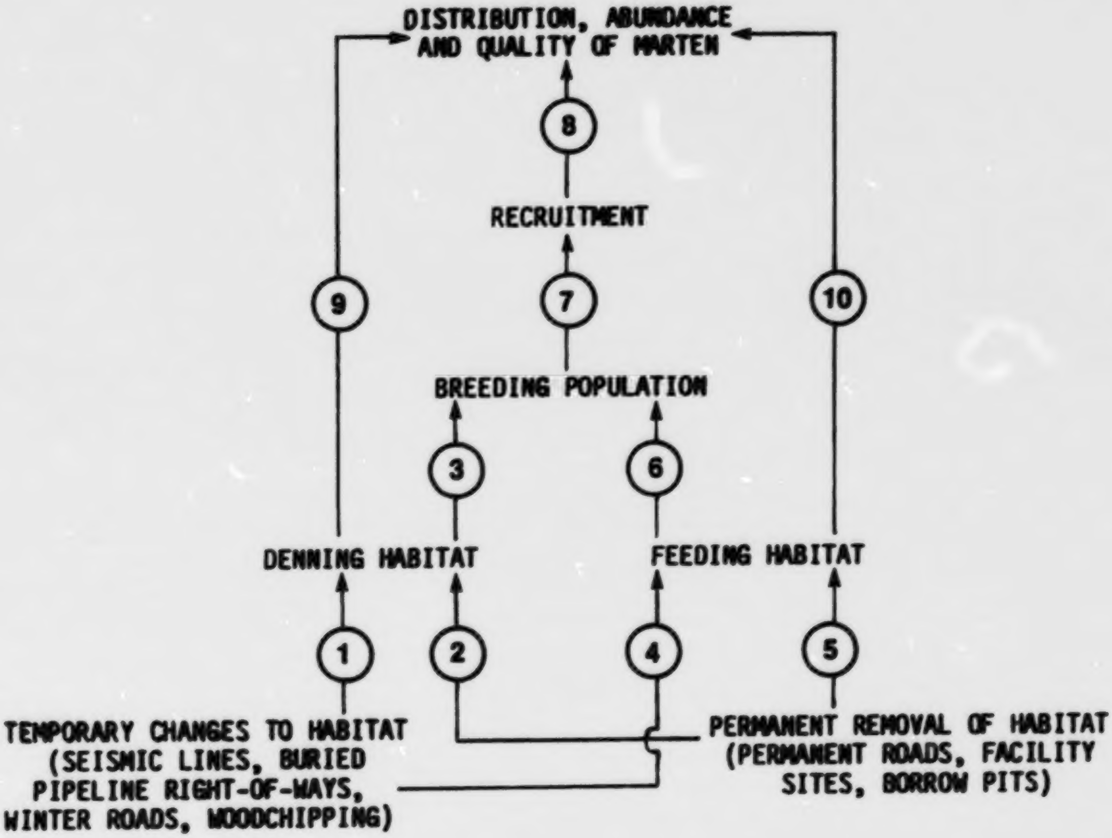
OIL AND GAS EXPLORATION AND DEVELOPMENT ACTIVITIES THAT ALTER HABITAT PERMANENTLY OR TEMPORARILY WILL INFLUENCE THE DISTRIBUTION AND ABUNDANCE OF MARTEN

For Hypothesis No. 6, the valued ecosystem component was marten. Conclusions reached were that this hypothesis was unlikely to be valid, and of low significance. Therefore, no specific studies were required.

The following material covers three project overviews relevant to this hypothesis.

HYPOTHESIS NO. 6

Oil and gas exploration and development activities that alter habitat permanently or temporarily will influence the distribution and abundance of marten


DISTRIBUTION, ABUNDANCE AND QUALITY OF MARTEN
8
RECRUITMENT
9
7
10
BREEDING POPULATION
3
6
DENNING HABITAT
FEEDING HABITAT
1
2
4
5
TEMPORARY CHANGES TO HABITAT (SEISMIC LINES, BURIED PIPELINE RIGHT-OF-WAYS, WINTER ROADS, WOODCHIPPING)
PERMANENT REMOVAL OF HABITAT (PERMANENT ROADS, FACILITY SITES, BORROW PITS)

LINKAGES

Link 1: Seismic lines, wood-chip operations, temporary winter roads and pipeline right-of-way will temporarily decrease marten denning habitat.

Link 2: Permanent roads, facility sites and borrow pits will permanently decrease marten denning habitat.

Link 3: A decrease in denning habitat will decrease the local breeding population of marten.

Link 4: Seismic lines, wood-chip operations, temporary winter roads and pipelines right-of-way will temporarily increase marten feeding habitat.

Link 5: Permanent roads, facility sites and borrow pits will permanently decrease marten feeding habitat.

Link 6: An increase in feeding habitat will increase the local breeding population of marten through increased survival.

Link 7: The size of the breeding population of marten influences recruitment.

Link 8: Recruitment contributes to marten population levels.

Link 9: A decrease in denning habitat will increase the emigration of marten to surrounding areas.

Link 10: An increase in feeding habitat will increase the immigration of marten from surrounding areas.

MEMP PROJECT OVERVIEW NO. 6-1

TITLE:	Responses of small mammals to forest harvesting in northern Maine.
PRINCIPAL INVESTIGATORS:	R.W. Monthey and E.C. Soutiere
AFFILIATION:	School of Forest Resources, University of Maine
FUNDING SOURCE:	Univ. Maine
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 6

BRIEF PROJECT OVERVIEW

Comparisons between relative abundance of small mammals in harvested and uncut softwood and hardwood stands were made between 1975 and 1977 in northern Maine. Twelve softwood clearcuts representing three successional stages (slash, *Rubus*, sapling), two partially cut stands and four uncut stands were snap-and-put trapped for 60,279 trap nights. The total small mammal community increased following harvesting in softwood stands. Red-backed voles were more common in slash and sapling stages and partially cut softwoods than in uncut softwoods. Deer mice were more abundant in uncut and partially-cut softwoods than in *Rubus* or sapling stages. Meadow voles preferred partially cut softwoods and the *Rubus* stage compared to uncut softwoods. Masked smokey shrews and pygmy shrews were collectively more common in harvested stands than in uncut softwoods or hardwoods.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report relates to Hypothesis 6, Link 4 which states that "seismic lines, wood-chip operations, temporary winter roads and pipeline right-of-ways will temporarily increase marten feeding habitat." The increase in the total small mammal community following logging in this study support this link.

MEMP PROJECT OVERVIEW NO. 6-2

TITLE:	Winter habitat use, food habits and home range size of the marten (Martes americana) in western Newfoundland.
PRINCIPAL INVESTIGATOR:	M.C. Bateman
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	CWS
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 6

BRIEF PROJECT DESCRIPTION

Habitat preferences of marten were determined from 51.6 km of snow tracking during the winters of 1980-81 and 1981-82. Marten selected mixed balsam fir-white birch stands and coniferous forest with high (>76%) overstory density. Marten travelled almost exclusively on the snow surface in winter, but frequently investigated subniveal tunnels by blowdowns and stumps. These access points may be important in prey accessibility. The most important prey species in winter were snowshoe hare and meadow vole which were identified in 51.8 and 30.4% of 56 scats analysed, respectively. Red squirrel was not found in scats although it was present in the study area. Winter ranges, as determined by radio telemetry, were 27.5 km^2 and 17.7 km^2 for a male and female marten, respectively.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study related to Hypothesis 6, Link 9 which states that "a decrease in denning habitat will increase the emigration of marten to surrounding areas". This study verifies that the preferred habitat of marten is coniferous and mixed-wood forests with high overstory diversity. It does not, however, indicate that a decline in the marten populations would occur if these habitats were removed. However, the low marten activity present in other habitats may indicate that emigration of marten could occur following clearing if other suitable habitats were available.

MEMP PROJECT OVERVIEW NO. 6-3

TITLE:	Microtines and ground squirrels of the coastal plain of the Arctic National Wildlife Refuge: notes on distributions, densities and general ecology.
PRINCIPAL INVESTIGATORS:	C.A. Babcock
AFFILIATION:	U.S. Fish and Wildlife Service and University of Alaska, Fairbanks, Alaska
FUNDING SOURCE:	U.S. Department of Interior
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 6

BRIEF PROJECT DESCRIPTION

A microtine rodent trapping survey was done at three locations across an altitude/coastal influence gradient in the Arctic National Wildlife Refuge from 31 May-25 August 1984. Each location was trapped three times at monthly intervals. A similar trapping program was done in 1983. Densities of *Microtus oeconomus* decreased at the more inland study areas between years. *Dicrostonyx torquatus* and *Lemmus sibericus* species were more common towards the coast. *Microtus miurus* occurred only at the most inland study site. Analysis of raptor pellets indicated that *Dicrostonyx* and *Lemmus* populations at the two more coastal sites may cycle or fluctuate. These populations appear to be in the second consecutive low density year. Habitat selection and partitioning by microtines appears to occur at low densities. Distribution of arctic ground squirrels (*Spermophilus parryii*) depends primarily on suitable burrowing conditions and forage quality. Herbivory by, and predatory use of, microtines and ground squirrels suggests their integral importance in the arctic ecosystem.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study relates to Hypothesis 6, Link 4 which states that "seismic lines, wood-chip operations, temporary winter roads and pipeline right-of-ways will temporarily increase marten feeding habitat." The analysis of microhabitat selection by small mammals conducted in this study provides information on the floristic components of the habitat which are selected or avoided by small mammals. The degree to which the plant cover selected by small mammals regenerates on the disturbed areas will determine the validity of this link of the hypothesis.

HYPOTHESIS NO. 7

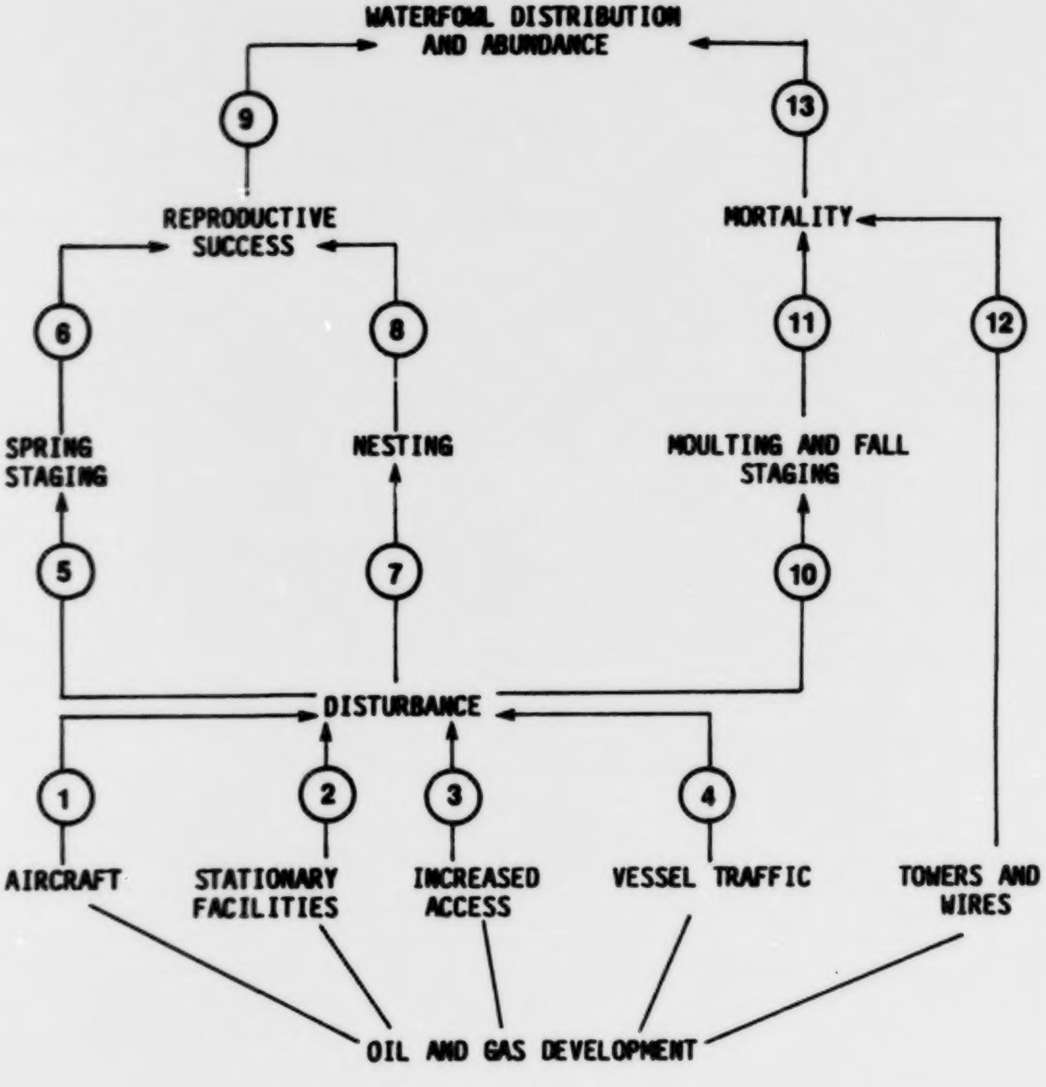
DISTURBANCE ASSOCIATED WITH HYDROCARBON DEVELOPMENT IN OR NEAR WATERFOWL STAGING, MOULTING OR NESTING AREAS WILL AFFECT THE ABUNDANCE AND DISTRIBUTION OF WATERFOWL

For Hypothesis No. 7, the valued ecosystem component was waterfowl. Conclusions reached were that this hypothesis was possibly valid, although detection would be difficult due to natural variations. It was recommended that possible effects could be mitigated through land use and reduction.

The following material covers four project overviews relevant to this hypothesis.

HYPOTHESIS NO. 7

Disturbance associated with hydrocarbon development in or near waterfowl staging, moulting or nesting areas will affect the abundance and distribution of waterfowl


WATERFOWL DISTRIBUTION AND ABUNDANCE
9
13
REPRODUCTIVE SUCCESS
MORTALITY
6
8
11
12
SPRING STAGING
NESTING
MOULTING AND FALL STAGING
5
7
10
DISTURBANCE
1
2
3
4
AIRCRAFT
STATIONARY FACILITIES
INCREASED ACCESS
VESSEL TRAFFIC
TOWERS AND WIRES
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Increases in aircraft overflights will increase disturbance to waterfowl.

Link 2: The presence of exploratory, processing and distribution facilities will increase disturbance to waterfowl.

Link 3: Increased access will increase disturbance to waterfowl.

Link 4: Increased vessel traffic on the Mackenzie River will increase disturbance to waterfowl.

Link 5: Increased disturbance will displace waterfowl in spring staging areas, and interfere with feeding, courtship and nesting.

Link 6: Increased energy costs due to displacement during spring staging will decrease reproductive success.

Link 7: An increase in disturbance will cause an increase in nest desertion and brood loss.

Link 8: Increased nest desertion and brood loss will decrease reproductive success.

Link 9: A decrease in reproductive success will reduce the abundance and alter the distribution of waterfowl.

Link 10: Increased levels of disturbance will increase energy costs during moulting and fall migration.

Link 11: Increased energy costs during moulting and fall migration will cause an increase in mortality.

Link 12: The presence of towers and wires will increase mortality of waterfowl.

Link 13: Increased mortality will reduce local abundance and alter the distribution of waterfowl.

MEMP PROJECT OVERVIEW NO. 7-1

TITLE: Influence of the Norman Wells Oilfield Expansion Project on snow geese.

PRINCIPAL INVESTIGATOR: P.N. Boothroyd

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: NOGAP

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 7

TITLE: Resolving production drilling restrictions and waterfowl disturbance concerns during spring migration at Norman Wells, Northwest Territories, Canada.

PRINCIPAL INVESTIGATORS: C.B. Sikstrom and P.N. Boothroyd

AFFILIATION: ESSO Resources Canada Ltd., Canadian Wildlife Service

FUNDING SOURCE: ESSO Resources Canada Ltd., NOGAP

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No. 7

TITLE: Spring use of the Mackenzie River by snow geese in relation to the Norman Wells Oilfield Expansion Project.

PRINCIPAL INVESTIGATOR: P.N. Boothroyd

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: NOGAP

COMPLETION DATE: 1985

Relevant MEMP Hypothesis: No. 7

BRIEF PROJECT DESCRIPTION

The overall objectives of the studies conducted by ESSO Resources Canada Ltd. and the Canadian Wildlife Service were to monitor the effects of development drilling of the Norman Wells oilfield on spring-staging waterfowl (primarily lesser snow geese) on islands in the Mackenzie River near Norman Wells. These MEMP project overviews summarize results of various studies conducted from 1980 to 1985 (Ealey and Scott-Brown 1984; R. Webb Environ. Serv. 1980, 1983, 1984; Boothroyd 1985, 1986; Sikstrom and Boothroyd 1985).

Study methods involved: 1) observations of behaviour; and 2) systematic aerial surveys. Behavioural observations of spring-staging geese were conducted in various riparian habitats, primarily at Bear, Goose, Rayuka and Little Bear islands, in relation to potential disturbances associated with nearby oilfield development. Major sources of disturbance were twin- and single engine fixed-wing aircraft, helicopters, trucks and some ground-based fixed sources. Systematic aerial surveys were conducted along sections of the Mackenzie River upstream and downstream of the Norman Wells development.

In general, oilfield development activities on production islands during spring had only minor and local impacts on staging waterfowl. Fluctuations in the distribution and abundance of waterfowl in the area were more affected by environmental factors such as weather and river water levels than by ESSO's drilling and support activities.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 7 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Links 1, 2 and 3 indicate that aircraft, stationary facilities and increased access will cause disturbance to waterfowl that stage, nest and moult in the area. The studies described in this overview provide information concerning the effects of aircraft overflights, truck movements and some stationary equipment on staging waterfowl (mainly snow geese); this information is directly relevant to the links noted above, and the results relate directly to the more significant final links of the hypothesis concerning reproductive success and overall population abundance and distribution.

MEMP PROJECT OVERVIEW NO. 7-2

TITLE: Behaviour of Pacific black brant and other geese in response to aircraft overflights and other disturbances at Izembek Lagoon, Alaska 1987.

PRINCIPAL INVESTIGATORS: D.H. Ward and R.A. Stehn

AFFILIATION: U.S. Fish and Wildlife Service

FUNDING SOURCE: U.S. Minerals Management Service

EXPECTED COMPLETION DATE: 1989

RELEVANT MEMP HYPOTHESIS: No. 7

TITLE: Behaviour of Pacific black brant and other geese in response to aircraft overflights and other disturbances at Izembek Lagoon, Alaska 1986.

PRINCIPAL INVESTIGATORS: D.H. Ward and R.A. Stehn

AFFILIATION: U.S. Fish and Wildlife Service

FUNDING SOURCE: U.S. Minerals Management Service

EXPECTED COMPLETION DATE: 1989

RELEVANT MEMP HYPOTHESIS: No. 7

BRIEF PROJECT DESCRIPTION

The objectives of this research are to: 1) determine the effect of aircraft overflights and other human activity on the behaviour, distribution and habitat use of brant and other geese at Izembek Lagoon, Alaska; and 2) evaluate the expected impact of disturbance on the energetics of migration and reproduction of geese. These objectives are being fulfilled by: 1) quantifying the behavioural responses of geese to disturbance; 2) identifying the spatial and temporal distribution patterns of geese; 3) determining the daily time and activity budgets of undisturbed geese; 4) estimating quantity and quality of food resources; and 5) developing a predictive model of energetic cost and potential habitat loss from disturbance. Izembek Lagoon, Alaska, is a major waterfowl staging area; during fall, virtually all the Pacific populations of some geese (black brant, emperor geese) congregate in Izembek Lagoon to feed prior to moving south to wintering areas.

The methods used in these studies involved observations of geese from various locations in Izembek Lagoon, with data on their numbers, distribution and behaviour in relation to habitat and potential disturbance source recorded at systematic intervals. The percentage of birds that exhibited each level of behavioural response was recorded for each flock in the study area, or estimated for all flocks in the study area as a whole.

So far, only preliminary results from annual reports of investigations are available. In general, however, lateral distance to an aircraft and height of an aircraft were the two best predictive variables associated with waterfowl disturbance; they described 33% and 99%, respectively, of the variation among the disturbance classes (continuous scale). Categorical variables (i.e., study area, observer, flock size, time of day, tide, date, temperature, size of aircraft, type of aircraft, wind direction) were examined through 1-way analysis of variance procedures. 'Observers' explained 17% of variation, 'data' explained 14% and 'aircraft size' explained 9%. Further studies and analyses are planned to obtain satisfactory curvilinear relationships between brant response and aircraft stimulus characteristics.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 7 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Links 1 and 3 indicate that aircraft and increased access will cause disturbance to waterfowl that stage, nest and moult in the area. The studies described in this overview provide information concerning the effects of aircraft overflights, and increased access on staging waterfowl (mainly geese); this information is directly relevant to the links noted above, and the results relate directly the more significant final links of the hypothesis concerning reproductive success and overall population abundance distribution.

MEMP PROJECT OVERVIEW NO. 7-3

TITLE: Preliminary assessment of the effects of the proposed Polar Gas pipeline and other hydrocarbon development projects on waterfowl of the northern Mackenzie Valley.

PRINCIPAL INVESTIGATOR: P. Boothroyd

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: CWS

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS; No. 7

BRIEF PROJECT DESCRIPTION

The principal objective of this study was to obtain current data on waterfowl densities directly along the proposed mainline and lateral pipeline routes and to determine the potential impacts of the Polar Gas project on waterfowl. In view of the recent discoveries of oil made by Gulf Canada Resources Inc. on the Amauligak structure in the Beaufort Sea, and the possibility of an oil pipeline being constructed from the northern tip of Richards Island, south through the Mackenzie River valley, consideration is also given in this study to the potential impacts on waterfowl of construction and operation of an oil pipeline and associated support facilities.

Study methods involved three aerial surveys of the proposed Polar Gas route during summer 1985 (26 June, 22 July and 26 August). All birds seen during the surveys were recorded on map sheets; results of 1985 surveys were compared with results of similar surveys conducted in 1973 and 1975. This report provides a good summary of the research by the Canadian Wildlife Service that is currently in progress; tentative results of recent and ongoing aircraft disturbance studies in the Mackenzie Delta area are discussed.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 7 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Links 1, 2 and 3 indicate that aircraft, stationary facilities and increased access will cause disturbance to waterfowl that stage, nest and moult in the areas. The studies described in this overview provide information concerning the effects of aircraft overflights during pipeline construction and operation, truck movements and some stationary equipment on staging waterfowl; this information is directly relevant to the links noted above, and the results relate directly to the more significant final links of the hypothesis concerning reproductive success and overall abundance and distribution of the population.

MEMP PROJECT OVERVIEW NO. 7-4

TITLE: Initial environmental evaluation of low-level military training flights in the Northwest Territories, Alberta and Saskatchewan-IR 920.

PRINCIPAL INVESTIGATOR: W. Duval

AFFILIATION: ESL Environmental Sciences Limited

FUNDING SOURCE: U.S. Air Force, Canada Department of National Defence

COMPLETION DATE; 1987

RELEVANT MEMP HYPOTHESIS: No.'s 7 and 8

TITLE: Initial environmental evaluation of low-level military training flights in British Columbia-IR 910.

PRINCIPAL INVESTIGATOR: W. Duval

AFFILIATION: ESL Environmental Sciences Limited

FUNDING SOURCE: U.S. Air Force, Canada Department of National Defence

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No.'s 7 and 8

BRIEF PROJECT DESCRIPTION

The objectives of both of these studies was to evaluate the environmental and social impacts of proposed low-level (as low as 122-500 m above ground level), subsonic military training flights along 13,000-15,000 km-long flight corridors traversing a variety of physiographic regions in three provinces (Alberta, Saskatchewan, British Columbia) and the Northwest Territories. The proposed flights were to be conducted during periods in March, May-June, September and November-December.

Study methods were similar to those employed during the Beaufort Environmental Monitoring Program (BEMP) and the Mackenzie Environmental Monitoring Program (MEMP). Project scenarios were described, Valued Ecosystem Components were determined and a series of hypotheses and associated linkages were constructed. Thorough information reviews were conducted and hypotheses and linkages were evaluated in light of all available information.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 7 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Link 1 indicates that aircraft will cause disturbance to waterfowl that stage, nest and moult in the area. The studies described in this overview provide relevant information concerning the effects on staging, moulting and nesting waterfowl of low-level aircraft overflights during military training exercises; this information is directly relevant to the link noted above, and the results relate directly to the more significant final links of the hypothesis concerning reproductive success and overall abundance and distribution of the population.

Hypothesis 8 describes a possible mechanism for environmental effects caused by hydrocarbon development near raptor nest sites. In this hypotheses the Valued Ecosystem Component is birds, namely raptors (hawks, eagles, falcons, ravens), that nest in the MEMP study area and may be affected by development activities. Link 7c indicates that aircraft overflights will cause disturbance to nesting raptors, and Links 8 and 9 indicate that such disturbance will affect raptor reproductive success and ultimately the distribution and abundance of raptors. The studies described in this overview provide relevant information concerning the effects on nesting raptors of low-level aircraft overflights and associated noise during military training exercises; this information is directly relevant to the links noted above.

MEMP PROJECT OVERVIEW NO. 7-5

TITLE: Key areas for birds in coastal regions of the Canadian Beaufort Sea.

PRINCIPAL INVESTIGATOR: S.A. Alexander

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: NOGAP

COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No.'s 7, 9 and 10

BRIEF PROJECT DESCRIPTION

Information pertaining to avian distribution and abundance along the Canadian Beaufort Sea coast was summarized and used to evaluate the importance of the coastline to birds, in a regional context. Seasonal differences in the requirements of birds were considered through separate evaluations in each of four time-periods: spring migration (May to mid-June), nesting (June to mid-July), moulting/broodrearing (mid-July to mid-August), and fall migration (mid-August to late September). The evaluations are presented in a series of ten maps as colour-coded delineations of regions of high, moderate, variable and low avian use. For each region in each time period there is a description of the major aspects of avian use (which may include comments on local population estimates, behaviour, year to year variation in numbers, and local movements of birds), and a listing of some of the data used in the evaluations. A general discussion on the limitations of the data used is presented in the introductory sections as an aid to the interpretation of information contained in the report.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 7 describes a possible mechanism for environmental affects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, molt or nest in the MEMP study area and may be affected by development activities in this area. Links 1,2 and 3 indicate that aircraft, stationary facilities and increased access will cause disturbance to waterfowl that stage, nest and moult in the area. The studies described in this overview provide information concerning the distribution and abundance of waterfowl, and this information is directly relevant to the links noted above. The results relate directly to the reproductive success and overall abundance of waterfowl.

HYPOTHESIS NO. 8

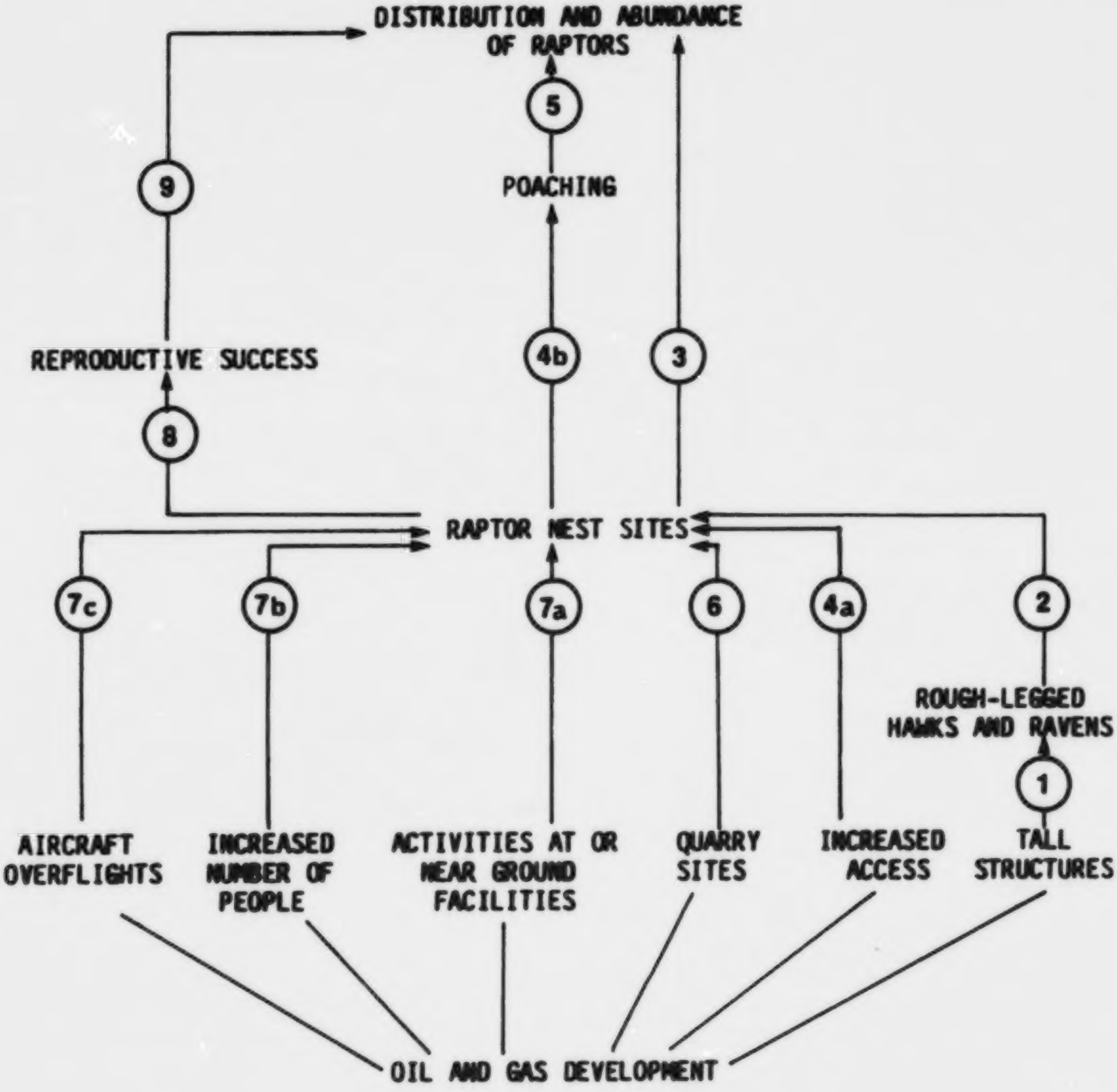
DISTURBANCE AND HABITAT ALTERATIONS DUE TO HYDROCARBON DEVELOPMENT WILL ALTER THE DISTRIBUTION AND/OR ABUNDANCE OF RAPTOR SPECIES

For Hypothesis No. 8, the valued ecosystem components were raptors. Conclusions reached were that this hypothesis was likely to be valid, but of low significance. No specific studies were recommended.

The following material covers two project overviews relevant to this hypothesis.

HYPOTHESIS NO. 8

Distribution and habitat alterations due to hydrocarbon development will alter the distribution and/or abundance of raptor species


DISTRIBUTION AND ABUNDANCE OF RAPTORS
5
POACHING
9
REPRODUCTIVE SUCCESS
8
4b
3
RAPTOR NEST SITES
7c
7b
7a
6
4a
2
ROUGH-LEGGED HAWKS AND RAVENS
1
AIRCRAFT OVERFLIGHTS
INCREASED NUMBER OF PEOPLE
ACTIVITIES AT OR NEAR GROUND FACILITIES
QUARRY SITES
INCREASED ACCESS
TALL STRUCTURES
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Ravens and rough-legged hawks will establish nest sites in tall structures.

Link 2: Gyrfalcons will take over some of the nests of ravens and/or rough-legged hawks that are int he tall structures.

Link 3: The presence of gyrfalcon nests in tall structures will result in an increase in the abundance and/or range of this species.

Link 4a: Roads, pipeline rights-of-way and seismic lines will allow access to raptor nest sites.

Link 4b: Increased access by people will result in increased poaching of eggs and young.

Link 5: Increased poaching will result in a reduction of peregrine falcon and gyrfalcon populations.

Link 6: Borrow sites can either create or destroy raptor nesting habitat.

Link 7a: Persistent aircraft activity at low altitudes will disturb nesting raptors.

Link 7b: An increase in the number of people in the area will result in disturbance to nesting raptors.

Link 7c: Activities at or near ground facilities will disturb nesting raptors.

Link 8: Disturbance at raptor nest sites will result in decreased reproductive success.

Link 9: A decrease in reproductive success will result in a reduction of raptor populations.

MEMP PROJECT OVERVIEW NO. 8-1

TITLE: Initial environmental evaluation of low-level military training flights in the Northwest Territories, Alberta and Saskatchewan-IR 920.

PRINCIPAL INVESTIGATOR: W. Duval

AFFILIATION: ESL Environmental Sciences Limited

FUNDING SOURCE: U.S. Air Force,Canada Department of National Defence

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No.'s 8 and 7

TITLE: Initial environmental evaluation of low-level military training flights in British Columbia-IR 910.

PRINCIPAL INVESTIGATOR: W. Duval

AFFILIATION: ESL Environmental Sciences Limited

FUNDING SOURCE: U.S. Air Force, Canada Department of National Defence

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No.'s 8 and 7

BRIEF PROJECT DESCRIPTION

The objectives of both of these studies was to evaluate the environmental and social impacts of proposed low-level (as low as 122-500 m above ground level), subsonic military training flights along 13,000-15,000 km-long flight corridors traversing a variety of physiographic regions in three provinces (Alberta, Saskatchewan, British Columbia) and the Northwest Territories. The proposed flights were to be conducted during periods in March, May-June, September and November-December.

Study methods were similar to those employed during the Beaufort Environmental Monitoring Program (BEMP) and the Mackenzie Environmental Monitoring Program (MEMP). Project scenarios were described, Valued Ecosystem Components were determined and a series of hypotheses and associated linkages were constructed. Thorough information reviews were conducted and hypotheses and linkages were evaluated in light of all available information.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 8 describes a possible mechanism for environmental effects caused by hydrocarbon development near raptor nest sites. In this hypothesis the Valued Ecosystem Component is birds, namely raptors (hawks, eagles, falcons, ravens) and owls, that nest in the MEMP study area and may be affected by development activities. Link 7c indicates that aircraft overflights will cause disturbance to nesting raptors, and Links 8 and 9 indicate that such disturbance will affect raptor reproductive success and ultimately the distribution and abundance of raptors. The studies described in this overview provide relevant information concerning the effects on nesting raptors of low-level aircraft overflights and associated noise during military training exercises; this information is directly relevant to the links noted above.

Hypothesis 7 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Link 1 indicates that aircraft will cause disturbance to waterfowl that stage, nest and moult in the area. The studies described in this overview provide relevant information concerning the effects on staging, moulting and nesting waterfowl of low-level aircraft overflights during military training exercises; this information is directly relevant to the link noted above, and the results relate directly to the more significant final links of the hypothesis concerning reproductive success and overall abundance and distribution of the population.

MEMP PROJECT OVERVIEW NO. 8-2

TITLE: Raptor monitoring program, Norman Wells Pipeline Project, 1987 progress report.

PRINCIPAL INVESTIGATOR: S.B. Matthews

AFFILIATION: Department of Renewable Resources, Government of Northwest Territories

FUNDING SOURCE: IPL, Government of Northwest Territories

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 8

TITLE: Raptor monitoring program, Norman Wells Pipeline Project, 1986 progress report.

PRINCIPAL INVESTIGATOR: S.B. Matthews

AFFILIATION: Department of Renewable Resources, Government of Northwest Territories

FUNDING SOURCE: IPL, Government of Northwest Territories

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 8

TITLE: Raptor monitoring program, Norman Wells Pipeline Project, 1985 progress report.

PRINCIPAL INVESTIGATOR: S.B. Matthews

AFFILIATION: Department of Renewable Resources, Government of Northwest Territories

FUNDING SOURCE: IPL, Government of Northwest Territories

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 8

TITLE:	Raptor monitoring program, Norman Wells Pipeline Project, 1984 progress report.
PRINCIPAL INVESTIGATOR:	S.B. Matthews
AFFILIATION:	Department of Renewable Resources, Government of Northwest Territories
FUNDING SOURCE:	IPL, Government of Northwest Territories
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 8

BRIEF PROJECT DESCRIPTION

The objectives of all years of raptor monitoring has been to document the distribution and abundance of falcons, eagles, hawks, raven and owls in the vicinity of IPL related activities and adjacent areas. Nest site attendance and the number of eggs and young birds were recorded and compared with data from earlier years (pre-construction and construction years).

Study methods involved aerial surveys and nest checks to determine the status of all raptor nests in and immediately adjacent to the study area.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 8 describes a possible mechanism for environmental effects caused by hydrocarbon development near raptor nest sites. In this hypothesis the Valued Ecosystem Component is birds, namely raptors (hawks, eagles, falcons, ravens) and owls, that nest in the MEMP study area and may be affected by development activities. Links 4, 6 and 7 indicate that tall structures, increased access, quarry sites, activities at or near ground facilities, increased numbers of people and aircraft overflights will cause disturbance to nesting raptors, and Links 8 and 9 indicate that such disturbance will affect raptor reproductive success and ultimately the distribution and abundance of raptors. Links 1, 2 and 3 indicate that tall structures constructed in association with IPL activities will attract nesting ravens and rough-legged hawks that will ultimately use falcon nests in subsequent years. The studies described in this overview provide relevant information concerning the effects on nesting raptors of IPL related activities; this information is directly relevant to the links noted above.

HYPOTHESIS NO. 9

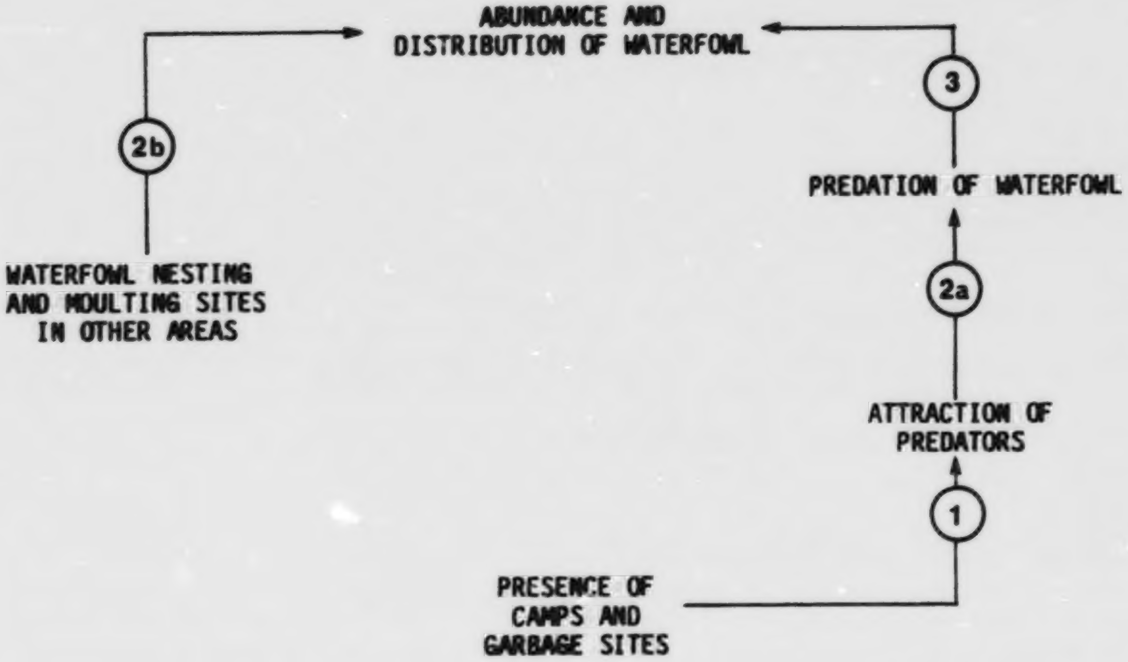
THE PRESENCE OF CAMPS AND GARBAGE DISPOSAL SITES WILL ATTRACT PREDATORS THAT WILL LEAD TO CHANGES IN THE LOCAL ABUNDANCE AND DISTRIBUTION OF WATERFOWL

For Hypothesis No. 9, the valued ecosystem component was waterfowl. Conclusions reached were that this hypothesis was valid but of low significance, and proper disposal practices were recommended.

The following material covers one project overview relevant to this hypothesis.

HYPOTHESIS NO. 9

The presence of camps and garbage disposal sites will attract predators that will lead to changes in local abundance and distribution of waterfowl


ABUNDANCE AND DISTRIBUTION OF WATERFOWL
3
PREDATION OF WATERFOWL
2a
ATTRACTION OF PREDATORS
1
PRESENCE OF CAMPS AND GARBAGE SITES
2b
WATERFOWL NESTING AND MOULTING SITES IN OTHER AREAS

LINKAGES

Link 1: The presence of camps and garbage disposal sites in an area will result in localized increases in the number of potential waterfowl predators (including bears, foxes, jaegers, gulls and ravens).

Link 2a: Nesting or moulting waterfowl near camps and garbage disposal sites will be subject to increased predation.

Link 2b: Waterfowl nesting or moulting away from camps and garbage disposal sites will be subjected to reduced predation.

Link 3: Increased predation of nesting and moulting waterfowl near camps and garbage disposal sites will cause a decrease in the abundance and alter the distribution of waterfowl.

MEMP PROJECT OVERVIEW NO. 9-1

TITLE:	Lisburne terrestrial monitoring program - 1985; the effects of the Lisburne Development Project on geese and swans.
PRINCIPAL INVESTIGATOR:	S.M. Murphy
AFFILIATION:	Alaska Biological Research
FUNDING SOURCE:	ARCO Alaska Inc.
COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No.'s 9 and 7

TITLE:	Lisburne terrestrial monitoring program - 1986; the effects of the Lisburne Development Project on geese and swans.
PRINCIPAL INVESTIGATOR:	S.M. Murphy
AFFILIATION:	Alaska Biological Research
FUNDING SOURCE:	ARCO Alaska Inc.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 9 and 7

BRIEF PROJECT DESCRIPTION

The primary goal of the 1985 and 1986 Lisburne monitoring programs was to evaluate the effects of Lisburne-related construction activities on Snow Geese, Brant, Canada Geese, Greater White-fronted Geese, and Tundra Swans, and to assess mortality and injury to birds in flight caused by the Lisburne powerline. To achieve these goals, the following objectives were pursued: 1) document abundance, distribution, and movements during the pre-nesting, nesting, brood-rearing/moulting, and fall staging; 2) monitor nest density and productivity; 3) evaluate interactions between predators and geese and swans (including the monitoring of predator populations); 4) record behaviour during pre-nesting, nesting, brood-rearing/moulting, and fall staging by documenting activity budgets and reactions to disturbance. Special attention was paid to the numbers of predatory Glaucous Gulls nesting close to the Lisburne Development Area (LDA). These gull populations are thought to have grown significantly since the development of the Prudhoe Bay oilfield and the accumulation of garbage (gull food).

The objectives of the powerline studies were as follows: 1) quantify the number of birds encountering the powerline, including information on species, season, and characteristics of the flight (i.e., altitude, direction); 2) evaluate which species and age classes of birds are most affected and evaluate which season, weather conditions, times of day, and configurations of the powerline are potentially hazardous to birds; and 3) estimate how many birds strike the powerline and how many of these strikes result in injury or mortality.

Disturbance investigation methods involved systematic observations of the behaviour of geese. Behavioural data were collected from observation towers, mobile tent blinds, and pick-up trucks. Data were collected in areas with various amounts of disturbance on activity budgets. Observations spanned the entire 24-h day in order to minimize bias resulting from diel fluctuations in activity patterns; the majority of data were collected during the period of highest oilfield activity (0600-1800 h). Special attention was given to the presence and activities of avian and mammalian predators.

Bird flights were systematically monitored from a stationary location at each of the 16 observation sections along 12.5 km of powerline. Sections of the powerline were categorized according to three criteria: 1) uniformity of the line configuration; 2) natural breaks in the line, such as changes in direction; and 3) a length suitable for observation purposes. Bird flights were monitored during 30-min periods for about 8-10 h per week between 24 May and 6 September. A variety of variables was recorded about environmental conditions and about the behaviour and height of birds crossing the lines, to determine whether avoidance behaviours occurred when birds encountered the line and to assess the potential for collisions with the line. Relatively sophisticated analyses of flight and behavioural data were conducted to arrive at estimates of collision mortality along the Lisburne powerline.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 9 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that moult or nest in the MEMP study area and may be affected by development activities in this area. Link 1 indicates that the presence of camps and associated garbage sites will attract predators. Link 2 indicates that these predators will in turn prey on nearby nesting and/or moulting waterfowl (and will avoid distant nesting or moulting waterfowl). Link 3 indicates that such predation (or lack thereof) will influence the abundance and distribution of waterfowl. The studies described in this overview provide relevant information concerning the consequence of garbage accumulation and handouts to predators that have accompanied hydrocarbon development in the Prudhoe Bay area of Alaska. This information is directly relevant to the links noted above, and the results relate directly to the more significant final links of the hypothesis concerning reproductive success and overall abundance and distribution of waterfowl.

Hypothesis 7 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Links 1, 2 and 3 indicate that aircraft, stationary facilities and increased access, respectively, will cause disturbance to waterfowl that stage, nest and moult in this area. The studies described in this overview provide relevant information concerning the effects on staging, moulting and nesting waterfowl of aircraft overflights, stationary facilities (drill rigs, pump stations), road and associated truck traffic and increased human access and consequent disturbance; this information is directly relevant to the links noted above, and the results relate directly to the more significant final links of the hypothesis concerning reproductive success and overall abundance and distribution of the population.

Link 12 indicates that towers and wires will cause increased mortality of waterfowl through collisions. The studies described in this overview provide relevant information concerning the effects on staging, moulting and nesting waterfowl of power line associated towers that pass through their habitat.

MEMP PROJECT OVERVIEW NO. 9-2

TITLE: Key areas for birds in coastal regions of the Canadian Beaufort Sea.

PRINCIPAL INVESTIGATOR: S.A. Alexander

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: NOGAP

COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No.'s 7, 9 and 10

BRIEF PROJECT DESCRIPTION

Information pertaining to avian distribution and abundance along the Canadian Beaufort Sea coast was summarized and used to evaluate the importance of the coastline to birds, in a regional context. Seasonal differences in the requirements of birds were considered through separate evaluations in each of four time-periods: spring migration (May to mid-June), nesting (June to mid-July), moulting/broodrearing (mid-July to mid-August), and fall migration (mid-August to late September). The evaluations are presented in a series of ten maps as colour-coded delineations of regions of high, moderate, variable and low avian use. For each region in each time period there is a description of the major aspects of avian use (which may include comments on local population estimates, behaviour, year to year variation in numbers, and local movements of birds), and a listing of some of the data used in the evaluations. A general discussion on the limitations of the data used is presented in the introductory sections as an aid to the interpretation of information contained in the report.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 9 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that moult or nest in the MEMP study area and may be affected by development activities in the area. Link 1 indicates that the presence of camps and associated garbage sites will attract predators. Link 2 indicates that these predators will in turn prey on nearby nesting and/or moulting waterfowl (and will avoid distant nesting or moulting waterfowl). Link 3 indicates that such predation (or lack thereof) will influence the abundance and distribution of waterfowl. The studies described in this overview provide relevant new information concerning the distribution and abundance of waterfowl in the Mackenzie Delta. This information is directly relevant to the links noted above, and the results relate directly to the reproductive success and overall abundance of waterfowl.

HYPOTHESIS NO. 10

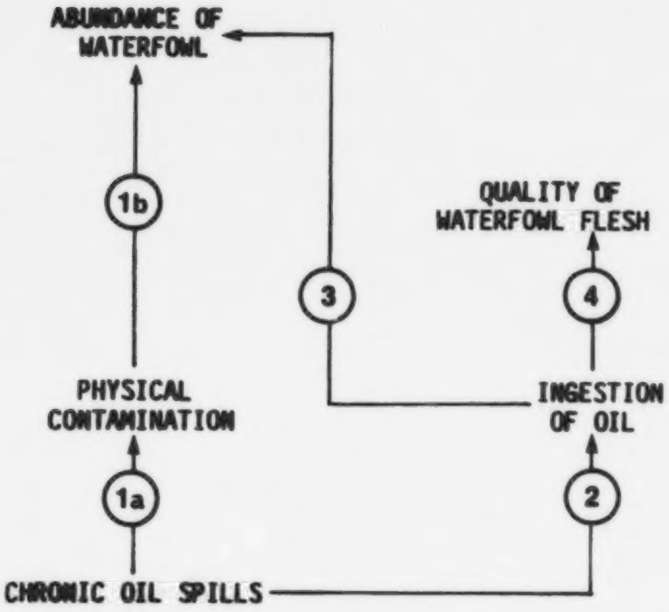
CHRONIC (EPISODIC) SPILLS OF CRUDE OIL AND DIESEL FUEL NEAR STAGING AND MOULTING AREAS OF NESTING COLONIES WILL REDUCE THE ABUNDANCE OF WATERFOWL

For Hypothesis No. 10, the valued ecosystem component was waterfowl. Conclusions reached were that this hypothesis was valid under some circumstances, but of low significance. It was recommended that mortality of birds resulting from oil spills be documented.

The following material covers two project overviews relevant to this hypothesis.

HYPOTHESIS NO. 10

Chronic (episodic) spills of crude oil and diesel near staging and moulting areas of nesting colonies will reduce the abundance of waterfowl


ABUNDANCE OF WATERFOWL
1b
3
QUALITY OF WATERFOWL FLESH
4
PHYSICAL CONTAMINATION
INGESTION OF OIL
1a
2
CHRONIC OIL SPILLS

LINKAGES

Link 1a: When susceptible bird species co-occur in space and time with the presence of an oil slick, physical contamination of the bird will occur.

Link 1b: Mortality of waterfowl will occur following physical contamination by oil.

Link 2: Waterfowl will consume oil through ingestion of contaminated food sources and preening of fouled plumage.

Link 3: Mortality of waterfowl will occur if oil is ingested.

Link 4: The quality of waterfowl flesh will be reduced if oil is ingested.

MEMP PROJECT OVERVIEW NO. 10-1

TITLE:	A hazard assessment of chemically dispersed oil spills and seabirds.
PRINCIPAL INVESTIGATOR:	D.B. Peakall
AFFILIATION:	Canadian Wildlife Service
FUNDING SOURCE:	CWS
COMPLETION DATE:	Completed (1987)
RELEVANT MEMP HYPOTHESIS;	No. 10

BRIEF PROJECT DESCRIPTION

This review contributes new information on the effects and potential hazards to birds (primarily seabirds) of exposure to and toxicity of dispersants and dispersed oil. The effects on two waterbird feeding regimes are considered: pursuit diving and surface diving. No original field or laboratory work was conducted in this study; the authors relied on already published work and on theoretical considerations and calculations.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 10 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Links 1, 2 and 3 indicate that chronic oil spills will cause physical contamination of birds and/or will result in birds ingesting oil -- these actions will increase mortality of local populations of waterfowl that stage, nest and moult in the area. The work reviewed in this overview provides relevant new information concerning the effects on staging, moulting and nesting waterfowl of chronic oil spills and of dispersants that may be used during clean-up activities. This information is directly relevant to the links noted above, and the results relate directly to the reproductive success and overall abundance of waterfowl.

MEMP PROJECT OVERVIEW NO. 10-2

TITLE:	Ecological characteristics of 35-year-old crude oil spills in tundra plant communities of the Mackenzie Mountains, N.W.T.
PRINCIPAL INVESTIGATORS:	G.P. Kershaw and L.J. Kershaw
AFFILIATION:	Department of Geography, University of Alberta and Arctic and Alpine Environmental Consulting
FUNDING SOURCE:	Boreal Inst. for Northern Studies, Arctic Inst. of N. America, Nat. Wild. Fed., Imperial Oil Ltd., and AMAX Northwest Mining Co.
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 10

BRIEF PROJECT DESCRIPTION

In June 1945 the CANOL Crude Oil Pipeline No. 1 from Norman Wells, Northwest Territories, to Whitehorse, Yukon Territory, was abandoned. During its short history, approximately 17,838,500 L of oil were lost through spills and 9,864,400 L were left in the line and storage tanks. Although some burning was done during salvage operations, most residual oil was drained onto the soil surface. Studies in alpine tundra indicate that this oil penetrated up to 60 cm in dry, coarse-textured soils and 8 cm in wet, clay-rich soil. Oil decomposition ranged from complete utilization of n-alkanes to selective metabolism of n-alkanes C_{12} to C_{19}. Contaminated soils were drier than control soils. This, plus surface blackening and thinning of organic surface layers, resulted in subsurface warming. Floristic similarity coefficients comparing control sites and 27 crude-oil spills varied from 19 to 52. Plant cover was substantially lower on oil spills and in only one community was floristic diversity greater on oil spills than on associated control sites. Dominant colonizers include *Cladonia pocillum*, *Cladonia pyxidata*, *Rinodina roscida*, *Carex aquatilis*, *Carex membranacea*, *Carex scirpoidea*, *Epilobium angustifolium*, *Eriophorum angustifolium*, *Festuca altaica*, *Juncus albescens*, *Poa alpina*, *Salix planifolia*, *Solidago multiradiata*, and *Trisetum spicatum*.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

No links of any of the hypotheses consider the effects of crude-oil spills on tundra plant communities. Hypothesis 10 considers the direct affect of oil spills on waterfowl, but does not examine indirect affects. A decrease in plant cover and floristic diversity is likely to affect the available food supply of some herbivores. The impact of the spill, will, of course, depend on its aerial extent.

MEMP PROJECT OVERVIEW NO. 10-3

TITLE: Key areas for birds in coastal regions of the Canadian Beaufort Sea.

PRINCIPAL INVESTIGATOR: S.A. Alexander

AFFILIATION: Canadian Wildlife Service

FUNDING SOURCE: NOGAP

COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No.'s 7, 9 and 10

BRIEF PROJECT DESCRIPTION

Information pertaining to avian distribution and abundance along the Canadian Beaufort Sea coast was summarized and used to evaluate the importance of the coastline to birds, in a regional context. Seasonal differences in the requirements of birds were considered through separate evaluations in each of four time-periods: spring migration (May to mid-June), nesting (June to mid-July), moulting/broodrearing (mid-July to mid-August), and fall migration (mid-August to late September). The evaluations are presented in a series of ten maps as colour-coded delineations of regions of high, moderate, variable and low avian use. For each region in each time period there is a description of the major aspects of avian use (which may include comments on local population estimates, behaviour, year to year variation in numbers, and local movements of birds), and a listing of some of the data used in the evaluations. A general discussion on the limitations of the data used is presented in the introductory sections as an aid to the interpretation of information contained in the report.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 10 describes a possible mechanism for environmental effects caused by hydrocarbon development in or near waterfowl staging, moulting or nesting areas. In this hypothesis the Valued Ecosystem Component is birds, namely waterfowl, that stage, moult or nest in the MEMP study area and may be affected by development activities in this area. Links 1, 2 and 3 indicate that chronic oil spills will cause physical contamination of birds, and/or will result in birds ingesting oil -- these actions will increase mortality in local populations of waterfowl that stage, nest and moult in the area. The work reviewed in this overview provides relevant new information concerning the distribution and abundance of waterfowl in the Mackenzie Delta and adjacent areas. This information is directly relevant to the links noted above, and the results relate directly to the reproductive success and overall abundance of waterfowl.

HYPOTHESIS NO. 11

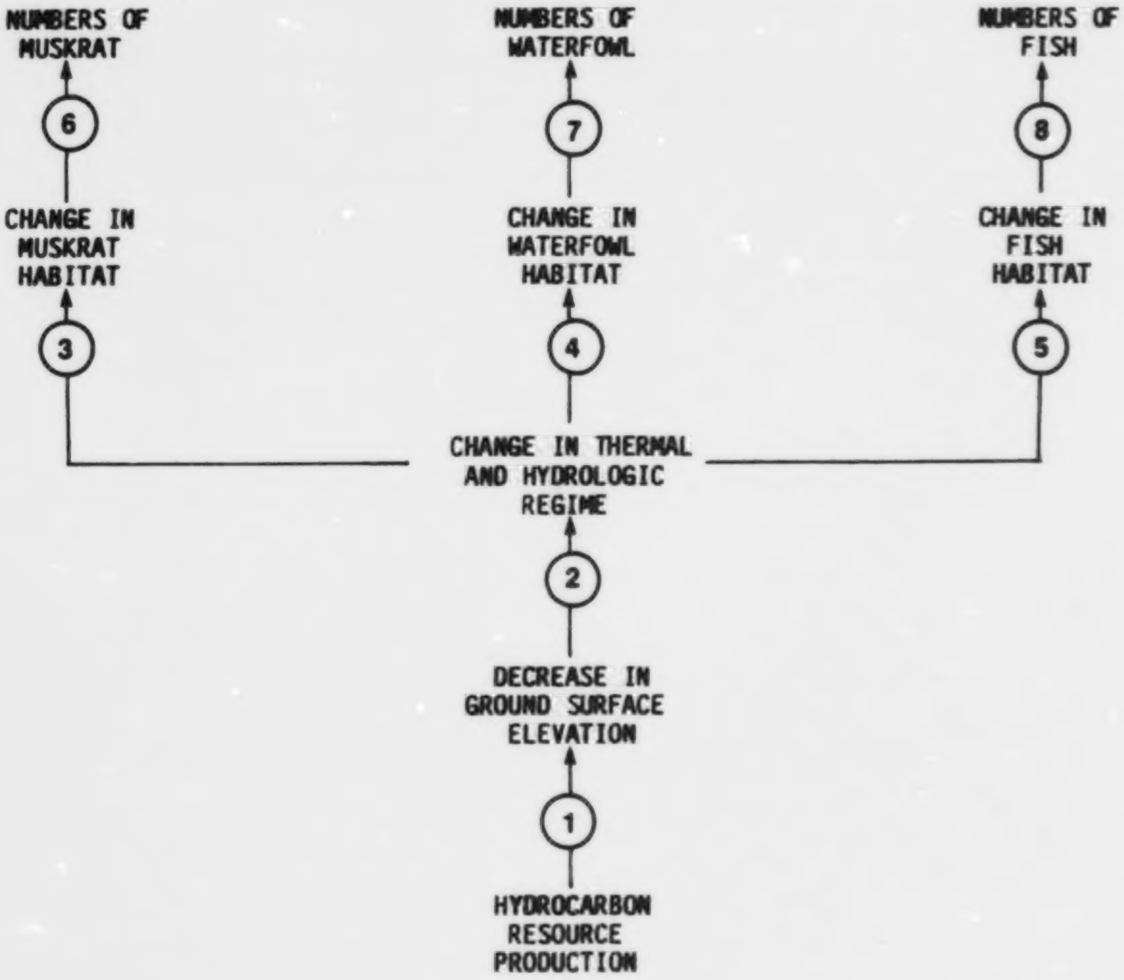
LAND SUBSIDENCE RESULTING FROM HYDROCARBON WITHDRAWAL WILL CHANGE THE ABUNDANCE AND DISTRIBUTION OF WATERFOWL, FISH AND MUSKRAT

For Hypothesis No. 11, the valued ecosystem components were waterfowl, fish and muskrat. Conclusions reached were that this hypothesis was unlikely to be significant if predictions on subsidence were correct. Since methods to predict subsidence are uncertain, studies were recommended on reservoir geology, terrain and permafrost distribution at Niglintgak. It was also recommended that ground surface elevations be monitored.

The following material covers four project overviews relevant to this hypothesis.

HYPOTHESIS NO. 11

Land subsidence resulting from hydrocarbon withdrawal will change the abundance and distribution of waterfowl, fish and muskrat


NUMBERS OF MUSKRAT
NUMBERS OF WATERFOWL
NUMBERS OF FISH
6
7
8
CHANGE IN MUSKRAT HABITAT
CHANGE IN WATERFOWL HABITAT
CHANGE IN FISH HABITAT
3
4
5
CHANGE IN THERMAL AND HYDROLOGIC REGIME
2
DECREASE IN GROUND SURFACE ELEVATION
1
HYDROCARBON RESOURCE PRODUCTION

LINKAGES

Link 1: Hydrocarbon production will cause subsidence of the ground surface overlying the Mackenzie Delta oil and gas fields.

Link 2: Subsidence of the ground surface will cause a change in the thermal and hydrological regime.

Links 3,4,5: A change in the thermal and hydrologic regime will cause a change in the area and quality of habitat for muskrat (Link 3), waterfowl (Link 4) and fish (Link 5).

Links 6,7,8: A change in the area and quality of habitat will cause a change in the numbers of muskrat (Link 6), waterfowl (Link 7) and fish (Link 8).

MEMP PROJECT OVERVIEW NO. 11-1

TITLE:	Geotechnical and geothermal conditions of nearshore sediments, southern Beaufort Sea, N.W.T.
PRINCIPAL INVESTIGATORS:	S. Dallimore, P. Kurfurst and J. Hunter
AFFILIATION:	Geological Survey of Canada
FUNDING SOURCE:	Department of Energy, Mines and Resources
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 11

BRIEF PROJECT DESCRIPTION

This study investigated permafrost characteristics along the southern Beaufort Sea and found substantial variability in geothermal and ground ice conditions in both nearshore and onshore sites. The implications of these findings on the design and construction of structures was discussed.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This paper provides evidence of the high degree of local variation in permafrost conditions in the Mackenzie Delta. Thaw consolidation and thermokarst activity resulting from induced land subsidence can be expected to show similar spatial variations.

MEMP PROJECT OVERVIEW NO. 11-2

TITLE:	Massive ground ice associated with glaciofluvial sediments, Richards Island, N.W.T.
PRINCIPAL INVESTIGATORS:	S. Dallimore and S.A. Wolfe
AFFILIATION:	Geological Survey of Canada
FUNDING SOURCE:	Department of Energy, Mines and Resources
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 11

BRIEF PROJECT DESCRIPTION

This study was an investigation of massive ground ice on Richards Island. Several ice types were found, including buried glacier ice and segregated epigenetic ice. Ice bodies were up to 20 m thick, but of great variability in thickness and in associated lithology.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This recent study is in the area of probable oil and gas removal and provides information on local ground ice conditions. The results show considerable lateral and vertical variability in ground ice distribution. Significant spatial variability in indirect subsidence, due to thermokarst or thaw consolidations must therefore be expected.

MEMP PROJECT OVERVIEW NO. 11-3

TITLE:	Mackenzie Delta sedimentary environments and processes.
PRINCIPAL INVESTIGATOR:	C.P. Lewis
AFFILIATION:	Environment Canada
FUNDING SOURCE:	Environment Canada
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 11

BRIEF PROJECT DESCRIPTION

The objective of this office programme was to amass and collate data and results relevant to all natural sedimentary environments and processes in the Mackenzie Delta, and to provide greater understanding of past, current and future sedimentation patterns. Published and unpublished data have been assembled and synthesized. The author identifies deficiencies in current understanding of sedimentary processes, and recommends studies to overcome these data gaps.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report includes material on natural subsidence but not on subsidence induced by oil and gas removal. A discussion is presented on the late Quaternary transgression and the ongoing relative sea level rise. Two more dates and a new sea level plot are provided, but the basic understanding remains unchanged. Calculations on thaw consolidation and associated ground subsidence are given which are relevant to Links 1, 2, 3, 4, and 5 of Hypothesis 11. Estimates of thaw consolidation and associated lake and channel development are valuable for the prediction of areal changes in muskrat, waterfowl and fish habitat.

Thus, the report indicates that any subsidence induced by oil and gas removal would be superimposed on a natural system of general basin subsidence and relative water level rise, and of thaw consolidation and lake and channel development. Owing to the lack of site-specific information on probable induced subsidence it is not possible to predict areal extent of changes.

HYPOTHESIS NO. 12

AIR EMISSIONS RESULTING FROM OIL AND GAS DEVELOPMENT AND OPERATION WILL ADVERSELY AFFECT AIR QUALITY

For Hypothesis No. 12, the valued ecosystem component was air quality. Conclusions reached were that this hypothesis was invalid. Compliance with operational permits was recommended. No relevant projects were identified for this hypothesis.

HYPOTHESIS NO. 12

Air emissions resulting from oil and gas development and operation will adversely affect air quality

AIR QUALITY
1
PRODUCTION ACTIVITIES

LINKAGES

Link 1: Air emissions from a number of sources will adversely affect air quality.

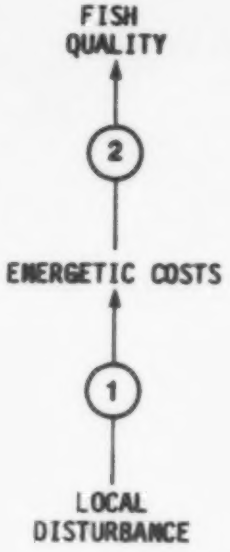
HYPOTHESIS NO. 13

INCREASED LOCAL DISTURBANCE DUE TO ACTIVITIES RELATED TO HYDROCARBON DEVELOPMENT WILL RESULT IN DECREASES IN FISH QUALITY

For Hypothesis No. 13, the valued ecosystem component was fish. Conclusions reached were that this hypothesis was invalid, and no recommendations were made. No relevant projects were identified for this hypothesis.

HYPOTHESIS NO. 13

Increased local disturbance due to activities related to hydrocarbon development will result in decreases in fish quality


FISH
QUALITY
2
ENERGETIC COSTS
1
LOCAL
DISTURBANCE

LINKAGES

Link 1: Increased local disturbance (e.g., from additional barge traffic) will result in energetic costs to fish in the areas of disturbance.

Link 2: Higher energy expenditure will result in decreased fish quality.

HYPOTHESIS NO. 14

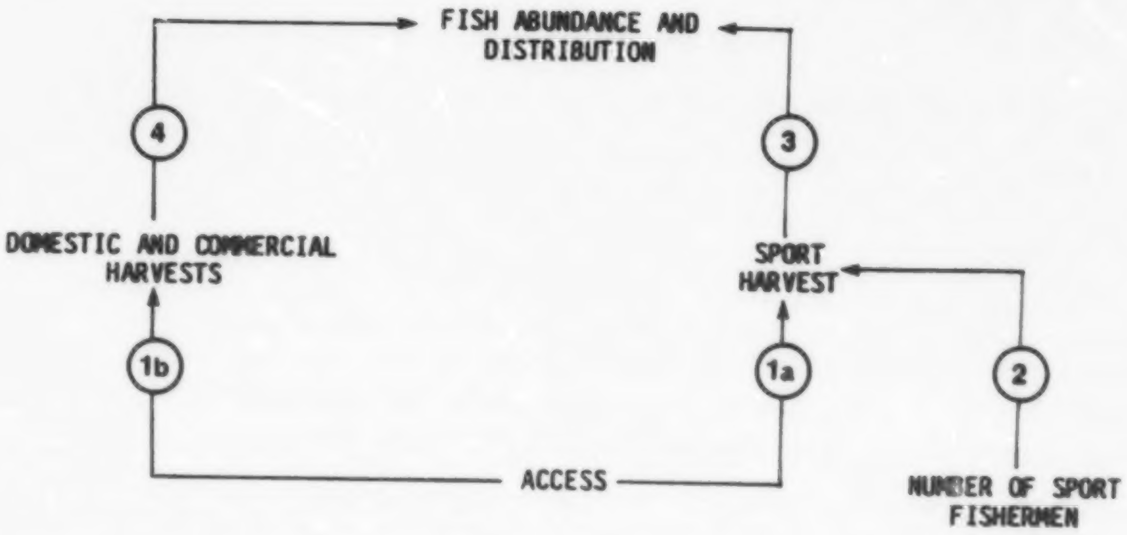
IMPROVED ACCESS AND FISHING PRESSURE WILL DECREASE THE ABUNDANCE OF FISH AND AFFECT THEIR DISTRIBUTION

For Hypothesis No. 14, the valued ecosystem component was fish. Conclusions reached were that this hypothesis was valid and that significant effects were likely. Distribution and population studies were recommended, along with investigations on population responses to exploitation and monitoring of harvests.

The following material covers seven project overviews relevant to this hypothesis.

HYPOTHESIS NO. 14

Improved access and fishing pressure will decrease the abundance of fish and affect their distribution


FISH ABUNDANCE AND DISTRIBUTION
4
3
DOMESTIC AND COMMERCIAL HARVESTS
SPORT HARVEST
1b
1a
2
ACCESS
NUMBER OF SPORT FISHERMEN

LINKAGES

Link 1: Improved access will increase sport, commercial and domestic harvests of fish.

Link 2: The number of recreational fishermen will increase due to industrial development; this will increase harvests of sport fish.

Link 3: Increased sport harvest will reduce local and regional populations of sport fish.

Link 4: Increased domestic and commercial harvests will reduce local and regional populations of fish, and alter their distribution.

MEMP PROJECT OVERVIEW NO. 14-1

TITLE:	Biological data on Arctic Charr, Salvelinus alpinus (L.), from the Rat River, Northwest Territories, 1983.
PRINCIPAL INVESTIGATORS:	D.V. Gillman and P.P. Sparling
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No.'s 14 and 23

BRIEF PROJECT DESCRIPTION

The annual migration of Arctic char to spawning and overwintering grounds on the Rat River provides the focus for an important domestic fishery for residents of Aklavik and Fort McPherson, Northwest Territories. Biological data (age, length, weight, sex, maturity, fecundity, condition) for Arctic char captured by a fish weir and trap on the Rat River during 1983 are presented in this report. A total of 1312 char were captured during August 1983 of which 752 were spawners and 560 were non-spawners. Enumeration of the 1983 upstream migration was incomplete since high water levels damaged the weir. Char sampled had a mean length of 413 mm, mean round weight of 1008 g and a mean age of 7 years.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report provides background data on the characteristics and abundance of the Arctic char populations in the Rat River. Without such information, change cannot be documented.

Due to its proximity to communities, Arctic char from the Rat River are subject to domestic fisheries.

MEMP PROJECT OVERVIEW NO. 14-2

TITLE: Arctic charr population studies: 1. Big Fish River; 2. river system survey 1984 (Yukon coast east to Victoria Island).

PRINCIPAL INVESTIGATOR: D.V. Gillman

AFFILIATION: Department of Fisheries and Oceans

FUNDING SOURCE: DFO

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No.'s 14 and 23

BRIEF PROJECT DESCRIPTION

This study, conducted in 1984, had the following two major objectives:

1. To provide an assessment of the total harvest of Arctic char taken by the domestic fishery from the Big Fish River to conduct a biological sampling program, to identify suitable locations for a fish fence, and to tag a segment of the population to aid in determination of movement and distribution; and

2. To survey rivers from the Yukon to Victoria Island to assess Arctic char habitat, potential spawning and overwintering areas and potential sites for fish weirs.

Three locations for counting fences were identified and 467 Arctic char were tagged. Biological data were collected from tagged char (sex and length) and from 192 char (round weight, length, sex, maturity, age) from the domestic catch. Their mean age was 7.7 years. The 1984 domestic catch of Arctic char from the Big Fish River was estimated to be 343 fish weighing about 325 kg in total.

Information collected during a brief survey in August-September 1984 is presented for 19 rivers.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

There is a general lack of annual information on present sport and domestic fish harvests in the study area. Without such baseline information, change in harvest levels cannot be detected.

MEMP PROJECT OVERVIEW NO. 14-3

TITLE:	Data from the monitoring of domestic/commercial fisheries for Arctic charr in the Big Fish River and Rat River areas, Northwest Territories 1986.
PRINCIPAL INVESTIGATOR:	P.D. Sparling
AFFILIATION:	Arctic Biological Consultants
FUNDING SOURCE:	DFO
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 14 and 23

BRIEF PROJECT DESCRIPTION

The objective of this study was to continue monitoring domestic and commercial catches of Arctic char (see Overview 14-1) and to collect biological data that are useful in monitoring fish populations.

Fishing generally took place from August to September, except for Cache Creek which was reached via snowmobile in October. Approximately 1660 Arctic char were taken from the latter area and catch per unit effort was very low during the last part of the fishery. Other locations where char were captured included Shingle Point (N=37), mouth of Big Fish River (N=197), Aklavik (N=11), Big Eddy (N=3), mouth of Rat River (N=714), and Destruction City (N=336).

Biological data collected on Arctic char included length, weight, age, sex, and condition factors and length-weight relationships were calculated.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study provides baseline information on annual fisheries without which the effects of improved access and increased fishing pressure cannot be assessed.

Although not directly induced by hydrocarbon exploration and development activities, the Arctic char fisheries in the Rat River and especially the Big Fish River/Cache Creek areas may be examples of how increased access results in greater fishing pressures and reduced fish populations. In recent years access to the Cache Creek area has been by snowmobile in early winter - a time when Arctic char are concentrated in small areas and are especially vulnerable to over-exploitation. It was reported that the last party to fish the Cache Creek area in 1986 had poor fishing success and generally only small Arctic char remained. Hence, increased access to the area, combined perhaps with increased demand, may have resulted in greater harvests and decreased Arctic char populations.

MEMP PROJECT OVERVIEW NO. 14-4

TITLE:	Broad whitefish stock differentiations.
PRINCIPAL INVESTIGATOR:	J. Reist
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO, NOGAP
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT MEMP HYPOTHESIS:	No. 14

BRIEF PROJECT DESCRIPTION

The purpose of this study is to determine the discreteness and number of broad whitefish stocks in the Mackenzie River drainage through morphometric, meristic and electrophoretic techniques. Samples of whitefish have been collected from the Mackenzie Delta and at several locations upstream. These specimens are being examined to determine the usefulness of specific characteristics as stock identifiers.

In 1986, approximately 1780 fish collected from the study area and from Alaska (for comparative purposes) during the 1985 field program were processed. This includes taking 20 measurements, 9 meristic counts and 4 measurements of biological parameters, examination for scarring and external parasites and extraction of muscle, heart and liver tissue for biochemical analysis. Scale-aging for all broad and lake whitefish collected in 1983, 1984 and 1985 has been completed, and analysis of all other species is presently being conducted.

Data analysis and report preparation are presently taking place.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is of general interest to all hypotheses concerning fish, since in many cases it is presently not known if one or more populations are present in a specific area at the same time. This is especially true in large rivers. Effects at the population level cannot be assessed if stocks cannot be separated.

MEMP PROJECT OVERVIEW NO. 14-5

TITLE:	Fishery data from Phillips Bay, Yukon, 1985.
PRINCIPAL INVESTIGATORS:	W.A. Bond and R.N. Erickson
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 14

BRIEF PROJECT OVERVIEW

Fish populations in the vicinity of Phillips Bay, Yukon coast, were sampled from 29 June to 21 August 1985 with variable mesh gill nets and small mesh seines. Seven anadromous species comprised 75% of the total catch. Among the anadromous species, Arctic cisco was the most abundant (77%), followed by least cisco (16%), rainbow smelt (5%), and Arctic char (2%). The only marine or brackish water species captured in significant numbers were fourhorn sculpin, which accounted for 85% of fish in this group, and Arctic flounder (14%). Catch statistics, associated water temperature and salinity figures, and biological data (length, weight, age, maturity, condition, food habits) are summarized in this report.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Many of the fishes captured in Phillips Bay originated from freshwater systems in the Yukon and western Northwest Territories. Thus, this study provides basic life-history information on these fishes while they are outside the MEMP study area.

MEMP PROJECT OVERVIEW NO. 14-6

TITLE: Fish distribution and abundance along the Yukon coast.

PRINCIPAL INVESTIGATORS: W.A. Bond and M. Lawrence

AFFILIATION: Department of Fisheries and Oceans

FUNDING SOURCE: DFO, NOGAP

EXPECTED COMPLETION DATE: 1988

RELEVANT MEMP HYPOTHESIS: No. 14

BRIEF PROJECT DESCRIPTION

The primary objectives of this study are to obtain baseline biological information on marine and anadromous fishes utilizing nearshore habitats along the Yukon coast including species composition, distribution, abundance, age, growth, sex, maturity, food habits, migratory habits and overwintering and spawning areas.

Gill nets, trapnets and seines were being used to sample fish between Kay Point and Calton Point. The 1986 sampling program focused on the area enclosed by the 5 m isobath within Phillips Bay. Sampling was initiated on 23 June and was completed by 8 September. Three traps were set; one inside Niakolik Point and a double trap on the seaward side of the point; these were operated on a daily basis. Three sites along the 5 m isobath were sampled on 23 occasions using variable-mesh gillnets, and six sites were sampled on a regular basis using small-mesh seines. Floy tags were applied to 2800 Arctic cisco. Water temperature and salinity were determined daily at each trapnet site and with each fish collection at seine and gillnet sites.

Seven anadromous species accounted for 59.2% of the total trapnet catch at Phillips Bay in 1986. Among anadromous species Arctic cisco were the most abundant (62.7%), followed by least cisco (24.2%), rainbow smelt (9.4%), and Arctic char (2.0%). Primary results of the study were as follows:

1. CPUE and mark recapture data suggest an early migration of large Arctic cisco through Phillips Bay and a late summer return to the Mackenzie Delta.

2. A large migration of young-of-the-year Arctic cisco arrived in Phillips Bay in mid-July, accompanied by substantial numbers of yearling fish. This migration peaked in early to mid-August but captures continued into September.

3. The length-frequency of Arctic cisco was strongly bi-modal, marked by a paucity of individuals in the 150-299 mm range. Of the total catch, 46.3% were between 50 and 79 mm fork length while 15.2% were in the 300-399 mm range.

4. CPUE values for large least cisco were highest in early summer but decreased in early August and remained low thereafter.

5. Least cisco showed a bi-modal length-frequency distribution; 39.9% were in the 80-169 mm range while 39.6% were between 270 and 329 mm. Young-of-the-year were seldom captured but a substantial number of age 1+ and 2+ (judging from length-frequencies) entered the study area in late July. The abundance of these small least cisco, which accounted for the smaller mode in the length-frequency distribution, decreased toward the end of the summer.

6. Arctic char captured during the study are presumed to belong to the Babbage River population and demonstrated the classic char migratory pattern.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is a continuation of that described in Project Overview 14-5.

MEMP PROJECT OVERVIEW NO. 14-7

TITLE:	External scarring of whitefish, *Coregonus nasus* and *C. clupeaformis* complex, from the western Northwest Territories, Canada.
PRINCIPAL INVESTIGATOR:	J.D. Reist
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 14

BRIEF PROJECT DESCRIPTION

Up to 40% of whitefish sampled during spawning migrations from the area of the Mackenzie Delta, N.W.T., had external scars. Percent frequency of scarred individuals varied geographically from the Mackenzie mainstem and tributaries, where 20% were scarred, to Anderson River (2%), Cox Lake (16%), and Alaska (0-7%). Within the Mackenzie system, fish captured at mainstem locations had approximately twice the frequency of scarring than did fish from tributary locations. Scars were classified as either slash or round type. Both scar types were located more frequently on the left side of the fishes and below the lateral line. Details of orientation and location on the body provided clues permitting the assignment of putative causation. Small round scars were restricted to locations with connections to the Arctic Ocean and were probably caused by the marine parasitic copepod *Coregonicola* or by Arctic lampreys (*Lampetra japonica*). Larger round scars were either the result of attacks by lampreys or by previous gillnet capture. Unequal distribution and orientation on the body of slash scars indicated previous capture in gill nets or predation attempts by bears, birds, or piscivorous fishes.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study illustrates the possible need to revise Hypothesis 14 since results indicate that increased fishing pressure could decrease the quality of fish. This could come about because scarring (caused by previous gillnet capture) could reduce the attractiveness and saleability of whitefish. A surprisingly large number of fish examined from the Mackenzie River were scarred. As noted in the report, this has definite implications for development of fisheries.

HYPOTHESIS NO. 15

WASTE DISCHARGES AND ACCIDENTAL OIL/CHEMICAL SPILLS WILL LEAD TO UNPOTABLE WATER AND DECREASED ACCEPTABILITY OF FISH AS A FOOD SOURCE

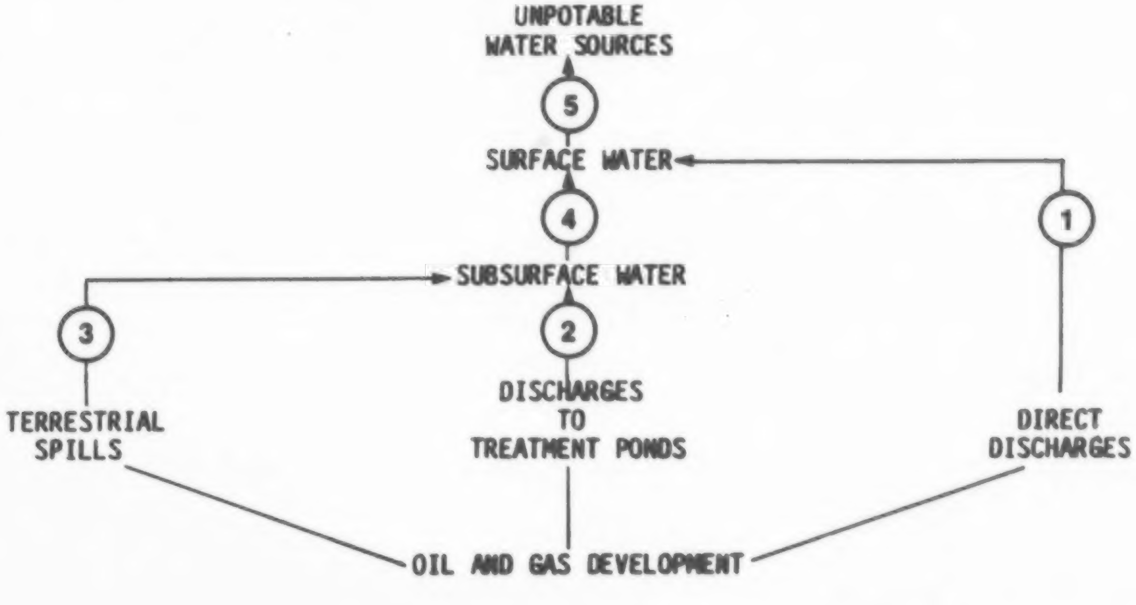
For Hypothesis No. 15, the valued ecosystem components were potable water and fish quality. Conclusions reached were that this hypothesis was unlikely, but local effects could be significant. It was recommended that the results of regional studies on potable water be monitored, and that present studies on metals and hydrocarbons in fish be continued.

The following material covers six project overviews relevant to this hypothesis.

HYPOTHESIS NO. 15A

Waste discharge and accidental oil/chemical spills will lead to unpotable water

HYPOTHESIS 15A


UNPOTABLE WATER SOURCES
5
SURFACE WATER
4
1
SUBSURFACE WATER
3
2
TERRESTRIAL SPILLS
DISCHARGES TO TREATMENT PONDS
DIRECT DISCHARGES
OIL AND GAS DEVELOPMENT

LINKAGES

Link 1: Direct discharges of contaminants to rivers, streams and lakes will increase their concentration in water.

Link 2: Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface water.

Link 3: Terrestrial spills of contaminants will lead to increased contaminant concentrations in subsurface water.

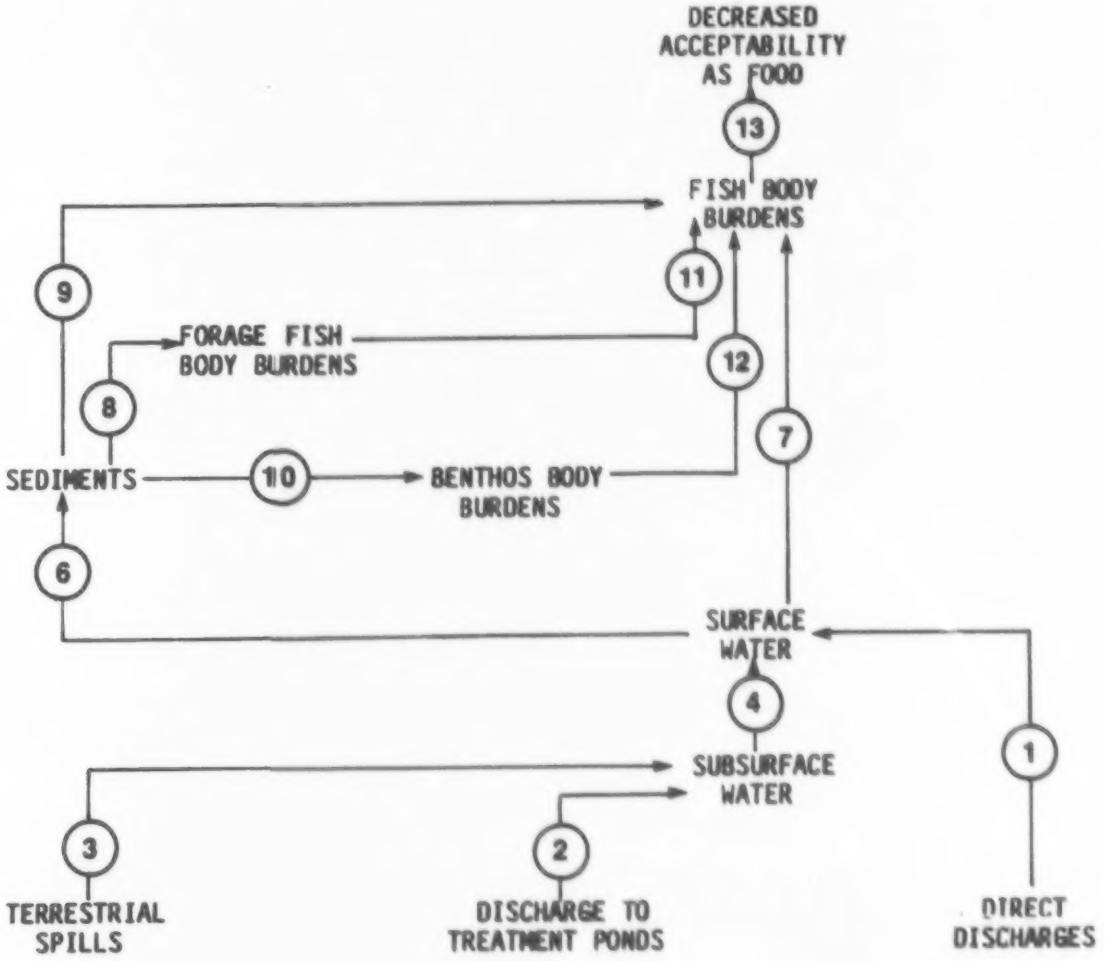
Link 4: Increased concentrations of contaminants in subsurface water will result in increased concentrations of these elements of compounds in surface water.

Link 5: Increased contaminant concentrations in surface water will lead to a decrease in the potability of water sources.

HYPOTHESIS NO. 15B

Waste discharge and accidental oil/chemical spills will lead to decreased acceptability of fish as a food source

HYPOTHESIS 15B


DECREASED ACCEPTABILITY AS FOOD
13
FISH BODY BURDENS
9
11
FORAGE FISH BODY BURDENS
12
8
7
SEDIMENTS
10
BENTHOS BODY BURDENS
6
SURFACE WATER
4
1
SUBSURFACE WATER
3
2
TERRESTRIAL SPILLS
DISCHARGE TO TREATMENT PONDS
DIRECT DISCHARGES

LINKAGES

Link 1: Direct discharge of contaminants into rivers, streams and lakes will increase their concentrations in water.

Link 2: Discharges of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface water.

Link 3: Terrestrial spills will lead to increased contaminant concentrations in subsurface water.

Link 4: Increased concentrations of contaminants in subsurface water will result in increased contaminant concentrations in surface water.

Link 5: Increased contaminant concentrations in surface water will result in increased contaminant concentrations in sediments.

Link 6: Increased contaminant concentrations in surface water will lead to contaminant uptake by fish.

Link 7: Increased contaminant concentrations in surface water will lead to increased contaminant body burdens in forage fish.

Link 8: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in bottom-feeding fish.

Link 9: Increased contaminant concentrations in sediments will lead to increased contaminant body burdens in benthic fauna.

Link 10: Increased contaminant body burdens in forage fish will lead to increased body burdens in predatory fish.

Link 11: Increased contaminant body burdens in benthos will lead to increased body burdens in bottom-feeding fish.

Link 12: Increased contaminant body burdens in fish will lead to decreased acceptability of fish as a food source by local residents.

MEMP PROJECT OVERVIEW NO. 15-1

TITLE:	The flux of suspended particulates, petroleum related hydrocarbons, trace metals and nutrients from the Mackenzie River during the winter season: a pilot study of the East Channel.
PRINCIPAL INVESTIGATOR:	Paul Erickson
AFFILIATION:	Arctic Laboratories Limited
FUNDING SOURCE:	Indian and Northern Affairs Canada
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 15

BRIEF PROJECT DESCRIPTION

The primary objectives of this study were: 1) to provide a time series of measurements of river discharge, sediment discharge, suspended sediment concentrations and detailed information on suspended particulate grain size distributions characterizing the winter flow regime of the East Channel of the Mackenzie River prior to entry into the Beaufort Sea; 2) to provide a concurrent time series of dissolved and particulate petroleum related hydrocarbons, trace metal and nutrient element concentrations; and 3) to evaluate the use of a moored in situ sampler for collecting time-integrated values for metals, hydrocarbons and suspended particulate matter.

Water and suspended particulates were collected through the ice in the East Channel of the Mackenzie River about 30 km upstream from Kittigazuit Bay in April 1985 and early February 1986. In February 1986, samples were also collected in the Main, Middle and Reindeer channels to compare fluxes in the other major channels.

The report presents a comprehensive data set of results for winter chemical water properties in the lower Mackenzie River, a long-awaited contribution to describing the chemical characteristics of the river. Data are presented for: 1) dissolved non-polar and aromatic hydrocarbons; 2) chlorinated hydrocarbons, Cu, Cd, As, Hg, Pb, V, Zn, Cr and Ni in the dissolved and particulate phases; 4) dissolved nitrate, silicate and orthophosphate; and 5) particulate organic carbon/particulate organic nitrogen.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This research addresses the river concentrations of contaminants identified as concerns in Hypothesis 15: "Waste discharges and accidental oil/chemical spills will lead to unpotable water and decreased acceptability of fish as a food source." These data will affect a recommendation made by the Hypothesis 15 subgroup at the 1986 MEMP Workshop, namely to obtain a better estimation of natural levels of hydrocarbons in the Mackenzie River. The data from this study will now allow a much better budget for contaminants in the Mackenzie River [illegible] be derived. This will allow a more realistic evaluation of the relative scales of possible development/industrial inputs and natural loading of contaminant chemical species.

MEMP PROJECT OVERVIEW NO. 15-2

TITLE:	Assessment of freshwater impacts from the Norman Wells Oilfield Development. Part III.
PRINCIPAL INVESTIGATOR:	B. Humphrey
AFFILIATION:	ESL Environmental Sciences Limited
FUNDING SOURCE:	Environment Canada, NOGAP
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 15

BRIEF PROJECT DESCRIPTION

This project is the third phase of a program to assess freshwater impacts from the Norman Wells Oilfield Development. Phase I addressed the characterization of the crude oil and refinery effluent and included a literature review of the fate and effects of hydrocarbons on the aquatic environment. During Phase II, the chemical characterization of the natural hydrocarbons from seeps was completed. A combination of laboratory and field tests was directed at the lethal and sub-lethal effects of the Norman Wells refinery effluent and of weathered material similar to natural seep hydrocarbons on burbot (Lota lota) and Arctic grayling (Thymallus arcticus). In addition, the water and sediments associated with the exposure tests were characterized and an examination of the effects of ice cover was made. The objectives of Phase III were: 1) to develop a water quality model based on hydrocarbon concentrations measured in the Mackenzie River at locations around Norman Wells; and 2) to determine whether a relationship exists between the health of burbot or arctic grayling and (a) location of collection or (b) chemical contaminants in the bile, liver and dorsal muscle of the fish.

The study results of Phase III indicated that there were no quantifiable hydrocarbons in the dissolved phase in the water column at quantification levels of about 1 ng L^{-1} for individual compounds. The suspended particulate matter was shown to contain trace levels of PAH, equivalent to about 1 ng L^{-1} of river water. Calculations of refinery effluent input to the Mackenzie River indicate that the maximum hydrocarbon input from the effluent could contaminate approximately 1% of the river at concentrations which could cause sub-lethal effects on the biota (25 ug L^{-1}). Higher concentrations would impact a smaller percentage of the river. The calculations referred to in the report suggest that, at present hydrocarbon input levels, the refinery effluent does not make a significant difference to the hydrocarbon levels which occur naturally in the river.

Chemical and histopathological analysis of burbot collected in the Norman Wells area indicated that no statistical correlation could be made between liver quality and chemical or histopathological parameters other than those which are symptomatic of the quality; low quality livers were low in lipid and were small relative to fish size. None of the hydrocarbon indicators such as bile PAH metabolite content correlated with the liver quality. Although extreme differences occurred in the quality of livers described in this study, no parameter examined could be implicated as contributing to the quality differences. Other parameters not examined here, such as parasitism or stress from other chemical pollutants such as chlorinated hydrocarbons, may have an effect, but future research will have to address those areas.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study provides some important data for examining Hypothesis 15. Although Link 1 ("Direct discharges of contaminants to rivers, streams and lakes will increase their concentrations in water") is generally valid, it may be true in the example of Norman Wells that rapid dilution of the effluent by the river or the effects of scavenging particulates may result in few instances of dissolved hydrocarbons exceeding the background levels. A careful examination of the results of this report and the chemical data given in the report on the "Pilot Study of the Chemistry of the Mackenzie River East Channel (MEMP Overview No. 15-1) should broaden the understanding of: 1) hydrocarbon/fish interactions in the Mackenzie River; and 2) the flux of hydrocarbons in the river and derivation of a crude hydrocarbon mass balance.

MEMP PROJECT OVERVIEW NO. 15-3

TITLE:	Assessment of freshwater impacts from the Norman Wells Oilfield Development. Part IV.
PRINCIPAL INVESTIGATOR:	S.E. Hrudey
AFFILIATION:	Steve. E. Hrudey and Associates Ltd.
FUNDING SOURCE:	Environment Canada, NOGAP
COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 15

BRIEF PROJECT DESCRIPTION

This report is an overview of the previous Parts I, II and III of the "Assessment of freshwater impacts from the Norman Wells Oilfield Development". In addition, studies conducted by DFO, Freshwater Institute into the factors responsible for fish quality in the Mackenzie River and the survey of ambient water quality throughout the length of the Mackenzie River conducted by Inland Waters Directorate, Environment Canada, have also been considered in the preparation of the overview report. The report provides a critical evaluation of previous studies and attempts to give an objective evaluation of the strengths and weaknesses of these studies.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study has relevance to Hypothesis 15 because it provides a large amount of information gathered from previous studies on the distribution and effects of contaminants in the Mackenzie River in a synthesis report. This allows for a greater definition of understanding of (1) the amount, fate and effects of contaminants; (2) hydrocarbons; and (3) fish quality in the river. The report also suggests possible future study needs including research and monitoring studies. consideration of these suggestions may be worth evaluating during the next workshop examination of this hypothesis.

MEMP PROJECT OVERVIEW NO. 15-4

TITLE: Geological assessment of waste drilling fluid contaminant sites in the Mackenzie River valley region, N.W.T.

PRINCIPAL INVESTIGATOR: Unknown

AFFILIATION: HARDY BBT Limited

FUNDING SOURCE: INAC, NOGAP

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No. 15

BRIEF PROJECT DESCRIPTION

The objectives of this study were: (1) to asses the performance of abandoned sumps to contain waste drilling fluids; and (2) to suggest improvements to the current drill waste management practice of "total contaminant". The assessment was carried out as a reconnaissance survey at eight abandoned sumps in the N.W.T. These sumps were located in a range of permafrost conditions and geographical locations as follows: (1) continuous permafrost in the Mackenzie Delta region (D52 Onigat; L28 Unak, D20 Parsons Lake); (2) discontinuous permafrost near the Mackenzie River at Norman Wells (B53 Windy Lake, B62 K'ALO, N37 Tunago); and (3) sporadic permafrost south of Fort Simpson (RJ29 Trout Lake, F8 North Trout Lake). The field survey took place in August 1987. At each abandoned sump (abandonment dates ranged from February 1977 to February 1987), conductivity measurements were made at the intersection points of a grid and a line spacing of 5-10 metres and covering the sump dimensions. In addition, soil samples were collected at each site from sampling locations selected on the basis of conductivity measurements. The study also included: (1) general reconnaissance at each site including a description of natural conditions and the permafrost condition; (2) preparation of sketches/photographs to document the location of transects and sampling locations; (3) analysis of soil samples for pH, conductivity and soluble K^+, Na^+, Mg^{++}, Cl- and $SO_4^=$; and (4) preparation of maps for each site to show areas of potential movements of contaminants from the sumps.

The evidence obtained in this study suggests that: (1) one sump (B53) leaks; (2) two sumps (D52 and D20) were rated as having a high probability of having leaked; (3) three sumps (F8, J29, N37) were rated as having some possibility of having leaded; (4) one sump (L28) was rated as a sump where containment of fluids within the sump was probable; and (5) one sump (B=62) was rated as a sump where containment was highly probably. The data do not indicate, however, the possible areal extent of movement of sump fluids out of the original containment sumps for those situations where leakage was considered probable or suspected.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study provides information for Link 2 (Hypothesis 15A), "Discharge of contaminants to treatment ponds will lead to increased contaminant concentrations in subsurface waters" and addresses a data gap identified at the 1986 MEMP Workshop. Although the results of this study cannot be applied to all geographic locations in the N.W.T., they do provide a much better basis upon which to justify the notion that contaminants can certainly migrate away from a drilling fluid containment sump. Additional investigations are still required to determine (1) the rate of sump fluid mobility and (2) correlations among composition of sump fluids, terrain factors, permeability of adjacent soils and the potential mobility of contaminants discharged to subsurface sumps.

MEMP PROJECT OVERVIEW NO. 15-5

TITLE:	Studies to determine whether the condition of fish from the Lower Mackenzie River is related to hydrocarbon exposure.
PRINCIPAL INVESTIGATOR:	W.L. Lockhart
AFFILIATION:	DFO, Freshwater Institute, Winnipeg
FUNDING SOURCE:	INAC, NOGAP
COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 15

BRIEF PROJECT DESCRIPTION

This study was conducted to investigate two complaints from the northern people, mainly those living in Fort Good Hope, related to the quality of fish from the Mackenzie River. Specifically, these complaints were that: (1) burbot livers were reported to have become small and dark in colour to the point that people would not eat them; and (2) the muscle of whitefish was reported to have become excessively "watery" with the result that these fish were less palatable than in the past. As these complaints began at the same time as the expansion of oil production at Norman Wells, the investigation focused on examining whether contamination from Norman Wells could be responsible for the deterioration of fish quality.

The main findings of this study were as described below:

1. Burbot livers were compared among fish collected from several northern communities, Lake Winnipeg, Southern Indian Lake, Manitoba and the Experimental Lakes area in northwestern Ontario. The occurrence of small dark livers was as severe at Fort Franklin, upstream from Norman Wells, as it was downstream from Norman Wells at Fort Good Hope and Arctic Red River. In addition, small dark livers were found in the burbot from Southern Indian Lake, but absent from burbot from Lake Winnipeg and from the Experimental Lakes area. This geographical distribution of the occurrence of small dark-coloured burbot livers led the investigators of this study to the conclusion that, if pollution is related to liver condition of burbot, then pollution from Norman Wells cannot be the exclusive cause.

2. Starvation experiments were conducted with two groups of burbot from Lake Winnipeg. One group received food; the other received none. The liver fats decreased in the starved group of fish, and livers generally became smaller and darker in colour. It was thus demonstrated that the liver condition reported in the Mackenzie River could be produced without pollution by reducing the liver fat,

although this cannot rule out pollution as an alternative cause of the condition.

3. Trout were exposed to Norman Wells oil in chronic laboratory experiments. Fish growth was reduced in both length and weight and the weight/length ratio decreased. This result has been repeated in a number of independent study with various fish species and types of oil. When length/weight data for fish obtained after the expansion activities at Norman Wells were compared with similar data obtained prior to development at Norman Wells, no difference was evident. Consequently, it appears that even if discharges from Norman Wells have an effect on the growth of fish, it is at a level below the noise of the existing data.

4. The induction of liver microsomal exodase enzymes was monitored following experimental treatment of burbot with Norman Wells oil in the laboratory. The induction of these enzymes is a sensitive index of the exposure of fish to petroleum hydrocarbons. There were no significant differences in the induction of these enzymes between fish from Fort Good Hope and those from Lake Winnipeg. This comparison was considered inconclusive because of the higher content of PCBs in Lake Winnipeg burbot, some congeners of which can also induce the target enzyme activities.

5. Fish from Fort Good Hope and other communities were found to contain low levels of several low-boiling hydrocarbons, notably ethylbenzene and xylenes. These compounds are among the most abundant compounds present in the "water soluble fraction" of Norman Wells Crude and other crude and refined oils. The observation that these hydrocarbons occurred in fish at much higher concentrations in winter, when volatization was at a minimum, than in summer, led the investigators to the conclusion that the river was a source of these materials. As natural oil seeps are common in the river drainage basin, the exact original source of these compounds (i.e., natural or development-related) could not be established.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of this study are relevant to the examination of whether the refinery operations ar Norman Wells could result in a deterioration of fish quality in the Mackenzie River. It is abundantly clear that the presence of hydrocarbons in fish can affect the quality and palatability of fish. What is unclear, even with the results of this well-conducted study, is whether hydrocarbons from the Norman Wells development actually do affect the quality of fish in the Mackenzie River. The weight of evidence at the present time would suggest that they do not.

MEMP PROJECT OVERVIEW NO. 15-6

TITLE:	Recommended laboratory methods for assessment of fish quality.
PRINCIPAL INVESTIGATOR:	A.D. Woyewoda
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 15 and 13

BRIEF PROJECT OVERVIEW

This report provides information on standard techniques and procedures for laboratory grading of fish quality to reduce disparity among testing facilities and provide a base from which technical staff and new personnel can obtain standard information.

Twenty-one laboratory procedures for scientific evaluation of fish quality were reviewed and in most cases, tested for applicability to Atlantic species. Each method is described in terms of application, principle of the method, precautions and notes, sample preparation, equipment, reagents, detailed procedure, calculations and typical examples.

Findings of laboratory testing undertaken during the study were incorporated into the report. The methods are not "state-of-the-art" or mechanized but rather utilize long-standing procedures which may be performed in moderately equipped laboratories. In many cases, newer methods are mentioned. The recommended methods have been tested and used by four DFO regional inspection laboratories and some fisheries institutes in Canada, Norway, Japan, and China. The comments concerning application of these techniques to various quality assessment operations in both research and routine work have been positive.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is pertinent to any hypothesis concerning quality of fish especially in terms of consumer preference and palatability. The latter are often subjective and changes in quality (e.g., taste, texture, etc.) are especially difficult to document. This report describes 'standardized' techniques that are often used in commercial grading of fishes. Similar techniques could be applicable to northern issues.

HYPOTHESIS NO. 16

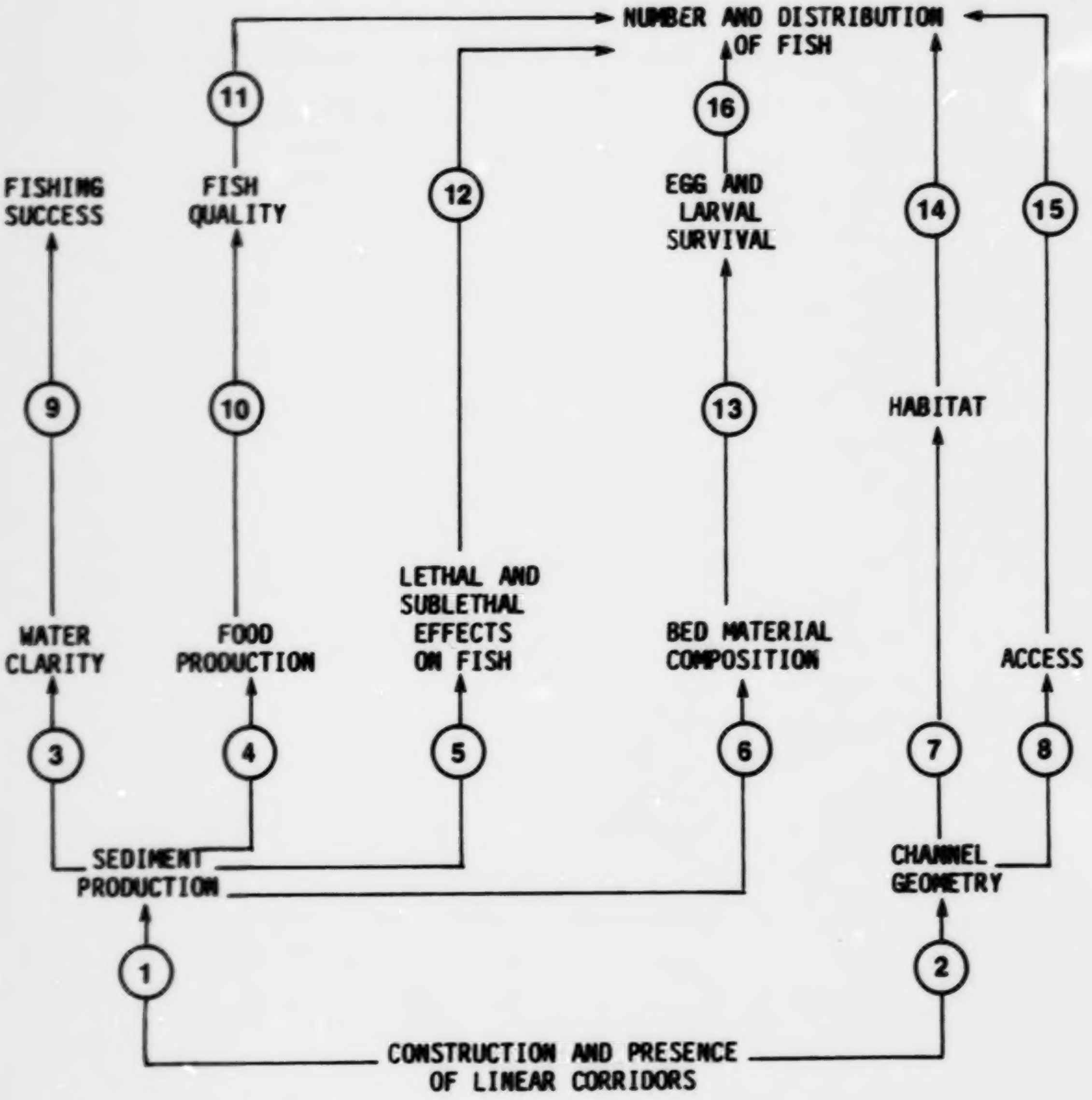
THE CONSTRUCTION AND PRESENCE OF LINEAR CORRIDORS WILL AFFECT THE NUMBER, DISTRIBUTION AND QUALITY OF FISH, AND FISHING SUCCESS

For Hypothesis No. 16, the valued ecosystem component was fish. Conclusions reached were that this hypothesis was valid and significant for fish numbers and distribution; and valid but insignificant for fish quality and fishing success. Mitigation of significant effects through known techniques was recommended; site-specific information on fish is required in most cases.

The following material describes 19 project overviews relevant to this hypothesis.

HYPOTHESIS NO. 16

The construction and presence of linear corridors will affect the number, distribution and quality of fish, and fishing success


NUMBER AND DISTRIBUTION OF FISH
11
16
FISHING SUCCESS
FISH QUALITY
12
EGG AND LARVAL SURVIVAL
14
15
9
10
13
HABITAT
LETHAL AND SUBLETHAL EFFECTS ON FISH
WATER CLARITY
FOOD PRODUCTION
BED MATERIAL COMPOSITION
ACCESS
3
4
5
6
7
8
SEDIMENT PRODUCTION
CHANNEL GEOMETRY
1
2
CONSTRUCTION AND PRESENCE OF LINEAR CORRIDORS

LINKAGES

Link 1: Construction and operation of linear corridors will increase rates of sediment production at specific locations or over large areas.

Link 2: Construction activities will alter channel geometry at specific locations.

Link 3: Increased rates of sediment production at specific locations will decrease water clarity.

Link 4: Increased rates of sediment production at specific locations will decrease the abundance or availability or prey species.

Link 5: Increased suspended sediment concentrations and exposure durations will have lethal and sublethal effects on fish and change their behaviour patterns.

Link 6: Local changes in sediment production will affect streambed material size.

Link 7: Alterations in channel morphology will directly affect the extent or distribution of in-stream habitat at specific locations.

Link 8: Local changes in channel geometry or thermal regime will result in blockage of fish movement.

Link 9: Local decreases in water clarity will decrease angling success and increase net fishing success.

Link 10: Local decreases in the production of prey organisms will reduce the size and quality of fish.

Link 11: Local decreases in the production of prey organisms will result in fish mortality or changes in their distribution.

Link 12: Fish avoidance, attraction or migrations due to high suspended sediment concentrations will affect the number and distribution of fish.

Link 13: Increased concentrations of fine-textured materials within the river bed will reduce egg and larval fish survival.

Link 14: Local changes in the amount and quality of habitat will change the number and distribution of fish.

Link 15: Local restrictions in access will reduce spawning or rearing success and overwinter survival and, therefore, affect the number and distribution of fish.

Link 16: Local decreases in fish egg and larval survival rates will reduce numbers and later the distribution of fish.

MEMP PROJECT OVERVIEW NO. 16-1

TITLE:	Water quality and biological survey of five streams in the vicinity of Stokes Point, Yukon-Beaufort Sea coast.
PRINCIPAL INVESTIGATOR:	R.B. Allan
AFFILIATION:	Environmental Protection Service
FUNDING SOURCE:	EPS
EXPECTED COMPLETION DATE:	1984
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

A baseline inventory of water chemistry, sediment, and biological conditions on five streams near Stokes Point and King Point was undertaken. The streams investigated included Deep Creek, Babbage, Trail, Crow, and Spring rivers. Sampling was conducted in August 1982 and August 1983.

The streams surveyed have been previously categorized as being either a mountain or tundra stream based on the origin of the headwaters region. The water chemistry of mountain streams was typically higher in pH, conductivity, filterable residue, alkalinity and hardness. This difference was further supported by higher concentrations of extractable calcium and magnesium in both the water and sediment samples from mountain streams.

Thirty-five species of benthic invertebrates were identified. Dipterans were the most dominant group both in terms of number of species and number of individuals collected. A new species of amphipod, Synurella sp., was collected. Bottom fauna data indicated that higher densities were associated with clean, gravel substrates, and sampling did not show any noticeable differences between the mountain and tundra stream types.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study provides background information on water quality and benthic invertebrates in streams that could be influenced by development along the Yukon coast.

MEMP PROJECT OVERVIEW NO. 16-2

TITLE:	Broad whitefish migratory patterns and critical areas.
PRINCIPAL INVESTIGATOR:	K. Chang-Kue
AFFILIATION:	Department of Fisheries and Oceans, Freshwater Institute
FUNDING SOURCE:	DFO, NOGAP
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

This study is investigating the movement of broad whitefish in the Mackenzie River streams on the Tuktoyaktuk Peninsula and in Mackenzie estuary areas to: 1) provide detailed information on the fall migration of broad whitefish; 2) identify major spawning grounds in Tuktoyaktuk Peninsula and Mackenzie Delta area (if any); and 3) identify overwintering habitats along the lower Mackenzie River and Delta. Earlier studies have indicated that juvenile broad whitefish summer in drainages on the Tuktoyaktuk Peninsula and winter either in the same drainage or in shallow coastal bays. Tagged fish were recovered years later as spawning migrants in the Mackenzie estuary.

In 1986, 25 broad whitefish in Kittigazit Creek were radio tagged to study the late summer and fall migration. The majority of these fish were immature (i.e., less than 8 years old). Late July tracking of these individuals indicated that they migrated downstream to the mouth of the creek within a week and made only very local movements within Kittigazit Inlet. By September, these fish still resided within the inlet, which support the hypothesis that immature coregonids migrate downstream and move into major coastal bays and possibly the outer Mackenzie Delta channels (e.g., East Channel) to overwinter.

Radio tagging of fish in Kittigazit Creek in 1987 confirmed 1986 results. In addition, 10 fish tagged in September 1987 in Kittigazit Inlet were still in the inlet in February 1988. This tends to confirm the importance of coastal bays as overwintering areas for broad whitefish.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

There is a general lack of information on life-history patterns of important fish in much of the MEMP study area. This study is relevant to Hypothesis 16 in that migratory patterns, overwintering areas and spawning areas of fish must be known in order to provide the background data that is necessary to test specific links in the hypothesis. The study identifies small streams on the Tuktoyaktuk Peninsula as important migratory routes for fish. Such small streams are also prone to disturbance in construction of linear developments.

MEMP PROJECT OVERVIEW NO. 16-3

TITLE:	The effect of winter pipeline construction on the fishes and fish habitat of Hodgson Creek, N.W.T.
PRINCIPAL INVESTIGATORS:	G.A. McKinnon and F.N. Hnytka
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT OVERVIEW

During the winter of 1984-85 a small (30.5 cm) diameter underground pipeline was built across Hodgson Creek, N.W.T. as part of a line from Norman Wells, N.W.T. to Zama, Alberta. The effects of construction and operation of this ambient temperature oil pipeline on fish and fish habitat in Hodgson Creek were studied from 1983 to 1987. There was no detectable effect of pipeline construction or operation on stream discharge, velocity, temperature, dissolved oxygen or water chemistry.

Winter bridge construction in December 1984 increased the instantaneous total suspended sediment (TSS) level from 2 mg L^{-1} to 26 mg L^{-1}. Seven hours later the TSS level equalled the pre-construction value. Pipeline trenching increased the TSS level from 1 mg L^{-1} to 3524 mg L^{-1}. Other construction activities including pipe-laying and back-filling produced lesser increases in TSS than did trenching. High levels attenuated quickly both over time and distance; four days after all in-stream construction ceased, the TSS values downstream of the construction site equalled pre-construction values. Twenty-four hour average deposition in sediment collectors placed 50 m downstream of the pipeline increased from <1 mg hr^{-1} to 140 mg hr^{-1} as a result of construction activity.

The headwaters of Hodgson Creek provide winter habitat for Arctic grayling (*Thymallus arcticus*), slimy sculpin (*Cottus cognatus*), and a small number of lake chub (*Couesius plumbeus*), longnose sucker (*Catostomus catostomus*), burbot (*Lota lota*) and northern pike (*Esox lucius*). Winter pipeline construction across the lower portion of this overwintering habitat appears to have had no effect on the fish which reside there during winter.

It is postulated that the Arctic grayling which overwinter in the headwaters of Hodgson do not comprise a resident population because no mature Arctic grayling were captured there during winter.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This project is relevant to Links 1, 2, 3, 5, and 7 of Hypothesis 16 since they are concerned with sediment, streambed morphology, turbidity and general quality of fish habitat at pipeline stream crossings. It should be noted that a general conclusion of the MEMP workshop in relation to Hypothesis 16 was that although the hypothesis was valid, the magnitude of effects could vary from nil or negligible to major, and that with appropriate planning and construction techniques, effects of pipeline crossings on fish would likely be minimal. This monitoring study appears to have validated this conclusion.

MEMP PROJECT OVERVIEW NO 16-4

TITLE: The effects of winter oil pipeline construction on the benthic macroinvertebrate community structure of Hodgson Creek, N.W.T.

PRINCIPAL INVESTIGATOR: P.J. Young

AFFILIATION: University of Guelph

FUNDING SOURCE: Univ. Guelph

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 16

BRIEF PROJECT DESCRIPTION

Studies were conducted during the ice-free seasons of 1984 and the winter and summer of 1985 to determine the effect of winter oil pipeline construction on the benthic macroinvertebrates of Hodgson Creek, N.W.T. Effects of winter in-stream construction were determined by assessing changes in drift densities; short-term effects were determined in the ice-free periods by examining changes in benthic density and community structure.

Downstream of the construction site, total suspended sediment (TSS) concentrations increased from 2 mg L^{-1} prior to construction, to over 300 mg L^{-1} during the construction period, with peak concentrations over 3000 mg L^{-1} being recorded. Silt deposition ranged from 15 to 78 g m^{-2} d^{-1} before construction, but increased to over 1500 g m^{-2} d^{-1} downstream of the construction site. Drift densities were significantly higher at the two stations receiving the highest silt deposition. *Capnia* sp. and *Alloperla* sp. numerically dominated the drift during this period. TSS concentrations returned to pre-construction values within five days of construction at all stations and the silt deposition rate decreased to 280 g m^{-2} d^{-1} downstream of the right-of-way five weeks following construction. Drift densities increased at the control station in late winter as *Capnia* sp. nymphs matured, while significantly lower drift densities were observed at two downstream stations. Densities of *Capnia* sp. apparently did not recover to pre-construction levels by the end of the winter study period.

TSS and nutrient concentrations were similar among stations in all ice-free sampling periods. Comparison of downstream and control stations prior to construction demonstrated no significant differences in species composition or community structure. Following ice scouring and spate events in the spring of 1985 (after construction), macroinvertebrate densities at all stations were approximately 100 m^{-2}. The substrate was quickly colonized by *Simulium* sp. and *Prosimulium* sp. and densities increased exponentially to over 1000 m^{-2} within 50 d of flooding. It appears that pipeline construction did not contribute to changes in habitat that would result in significant changes in community structure or benthic densities.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is of direct relevance to Link 4 of Hypothesis 16 which is concerned with the effects of increased sediments on fish foods. The study indicated that effects of the pipeline crossing were minor and of a short-term nature.

MEMP PROJECT OVERVIEW NO. 16-5

TITLE:	Fish passage assessment of culverts constructed to simulate stream conditions on Liard River tributaries.
PRINCIPAL INVESTIGATORS:	G.A. McKinnon and F.N. Hnytka
AFFILIATION:	Department of Fisheries and Oceans
FUNDING SOURCE:	DFO
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

From 1978 to 1981 four small streams crossed by the Liard Highway were studied to assess the effects of culverts on fish. The culverts were constructed in 1979 and rock riprap was placed on the culvert floor to provide areas of low water velocity for migrating fish. Stream grade and cross-sectional dimensions were used to set culvert slope and size. This approach, named "stream simulation", attempts to simulate natural rapids that present no difficulty to migrating fish.

Flow levels in all four streams varied widely but did not exceed the mean annual flood estimated by hydrologic analysis, any of the four years of study.

Culvert riprap, when not buried by sediment, was effective in reducing current velocities. An added benefit was that culvert icing became suspended by culvert riprap allowing flow and, subsequently, fish migration under the ice between boulders. The culverts did not present a barrier to fish migration in any year of study.

The highway crossing of the streams varied from 3.7 to 5.1 km upstream of the Liard River confluence. Spawning migrations of Arctic grayling (*Thymallus arcticus*) and longnose sucker (*Catastomus catastomus*) at the highway crossing occurred in three of the four streams studied; one stream also had significant numbers of northern pike (*Esox lucius*).

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is relevant to Link 8 of Hypothesis 16 since it was concerned with culverts and maintenance of fish passage. It should be noted that this study provides some information on possible culvert design and installation techniques to permit fish passage during ice cover. This was a specific research need (discussed at the MEMP workshop -- see p. 206 of INAC et al. 1986).

MEMP PROJECT OVERVIEW NO. 16-6

TITLE: Responses of Arctic grayling (*Thymallus arcticus*) to acute and prolonged exposure to Yukon placer mining sediment.

PRINCIPAL INVESTIGATORS: D.J. McLeay and I.K. Birtwell

AFFILIATION: Norecol Limited and Department of Fisheries and Oceans

FUNDING SOURCE: DFO

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No. 16

BRIEF PROJECT DESCRIPTION

Underyearling Arctic grayling (*Thymallus arcticus*) from the Yukon River system were exposed for 4 d to suspensions of fine inorganic (<250 g L^{-1}) and organic (<50 g L^{-1}) sediment and for 6 weeks to inorganic sediment (<1000 mg L^{-1}) under laboratory conditions. The test sediments were collected from an active placer mining area near Mayo, Yukon Territory. The exposures evoked sublethal responses but did not cause gill damage. Mortalities (10 and 20%) occurred only in experiments at 5°C with inorganic sediment concentrations >20 g L^{-1}. Six weeks of exposure to sediment concentrations >100 mg L^{-1} impaired feeding activity, reduced growth rates, caused downstream displacement, colour changes, and decreased resistance to the reference toxicant pentachlorophenol, but did not impair respiratory capabilities. Stress responses (elevated and/or more varied blood sugar levels, depressed leucocrit values) were recorded after short exposure (1-4 d) to organic sediment concentrations as low as 50 mg L^{-1}. Inorganic sediment strengths >10 g L^{-1} caused fish to surface. The lethal and sublethal responses of Arctic grayling to pentachlorophenol were similar to those determined for other healthy salmonid fishes.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is directly relevant to Links 1, 4 and 5 of Hypothesis 16 which deals with the effects of sediment on fish. There is a serious lack of this type of information in relation to arctic and northern fish; hence, this research is especially pertinent to MEMP.

MEMP PROJECT OVERVIEW NO. 16-7

TITLE: Western arctic fish collections 1983-1986: sample-processing procedures and basic data on individual specimens.

PRINCIPAL INVESTIGATOR: J.D. Reist

AFFILIATION: Department of Fisheries and Oceans

FUNDING SOURCE: DFO

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS; No. 16

BRIEF PROJECT DESCRIPTION

Five thousand six hundred and seven fish representing 23 species were collected from 1983 to 1986 from several locations in the western North American Arctic. Of these, 3747 have been processed to date. This report outlines the general procedures of processing which provides a variety of data and tissues from these samples for use in other studies. Processing involved the collection of biological, morphological and meristic data and the removal of tissues for further analyses. Basic background information on the specimens is provided herein. These data are details of collection information, basic biological data (fork and standard lengths, weight, sex, and maturity), and a unique identification number assigned to each individual. The unique identification number permits cross-referencing back to the individual of all data accrued in subsequent analyses.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report provides curatological information on fish collections that have been used in studies such as that described in MEMP Project Overview 16-2 and 14-4.

MEMP PROJECT OVERVIEW NO. 16-8

TITLE:	Aquatic monitoring survey, Norman Wells to Zama pipeline, July 1985.
PRINCIPAL INVESTIGATOR:	D.A. Fernet
AFFILIATION:	Environmental Management Associates
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

This report describes the first year of a three-year monitoring program. The entire investigation is summarized in MEMP Project Overview No. 16-10.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is of direct relevance to Hypothesis 16 which is concerned with the effects of linear development, especially pipeline construction.

MEMP PROJECT OVERVIEW NO. 16-9

TITLE:	Aquatic monitoring survey, Norman Wells to Zama pipeline, July 1986.
PRINCIPAL INVESTIGATOR:	D.A. Fernet
AFFILIATION:	Environmental Management Association
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

This report describes the second year of a three-year monitoring program. The entire investigation is summarized in MEMP Overview No. 16-10.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is of direct relevance to Hypothesis 16 which is concerned with the effects of linear development, especially pipeline construction.

MEMP PROJECT OVERVIEW NO. 16-10

TITLE:	Aquatic monitoring studies of the Norman Wells to Zama Oil pipeline, 1984-1987.
PRINCIPAL INVESTIGATOR:	D.A. Fernet
AFFILIATION:	Environmental Management Associates
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

Due to the importance and direct relevance of this monitoring study to MEMP, the entire executive summary of this report is provided below. Note that opinions are those of the author.

> "The Norman Wells to Zama Oil Pipeline was constructed in 1984 and 1985, with the majority of construction occurring during the winter months. Watercrossings along the pipeline route were examined during the summers of 1984, 1985 and 1986 to determine if pipeline construction or operation was contributing to the degradation of aquatic habitats or water quality along the pipeline route (Fernet 1984b, 1985, 1986). A comparable survey was conducted in July, 1987 during which virtually all watercrossings along the pipeline route were examined. Larger watercrossings were examined from the ground, at which time the approaches were examined for stability (evidence of erosion, revegetation success), and the instream ditchline, upstream and downstream areas were examined for habitat quality (evidence of sedimentation, blockages or alterations, or evidence of any apparent degradation of water quality). Smaller watercrossings were examined during the helicopter overflight of the pipeline route; these crossings were examined for any indications of instability.
>
> "Detailed watercrossing evaluations were completed for the 34 major crossings along the pipeline route in each survey year; the results of the 1987 program are presented together with a photograph of the conditions at each crossing in this document. A summary of relevant comments on the 181 minor watercrossings is presented in tabular form, as was the case with previous reports. No aquatic concerns which were judged to require maintenance activities were noted at any of the minor crossings in 1987, while only very few were apparent at the larger watercourses.
>
> "The results of the four year monitoring program are described, with emphasis placed on common concerns noted during these surveys and the condition of watercrossings at the time of the 1987 reconnaissance. Two major concerns were noted throughout the program, the first of which was subsidence on the ditchline at watercrossings. This condition developed as a result of using very deep sag bends at

watercrossings, without attempting to compact the backfill. The second major concern commonly noted was insufficient streambank protection on many watercrossings. This situation arose largely as a result of the inaccessibility of suitably sized granular material for this purpose. Biodegradable sandbags were used during the winter 1984 construction period for the protection of some streambanks, but this practice was discontinued as the sandbags were found to degrade prior to any revegetation or stabilization of the banks.

"The incidence of subsidence and ponding at watercrossing locations was noted very infrequently in 1987, due to the remedial maintenance activities of IPL. At the minor watercrossings where this condition was noted, the crossing locations were judged to be stable. Although comments were made on 23 of the minor watercrossings in 1987, virtually all appeared to be stable and none were noted to require remedial maintenance activities.

"Most of the concerns noted in 1987 were minor in nature, with the recommendation that the conditions be monitored to ensure a stable environment develops. A concern was raised regarding the lack of backfill across the islands in the Whitesand Creek tributary (Kmp 27.1), due to channelization of water along the ditchline and the exposure of a relatively large, unstable surface area which would be prone to erosion during high creek stages. Some sandbag streambank protection still exists at the Seagrams Creek crossing, which is a situation that should be corrected. Several other minor concerns are also noted in text, such as the failure to remove a winter log bridge at the Whitesand Creek tributary (Kmp 271.1), and the presence of log jams at Helava and Whitesand creeks which appear to be responsible for retarding the stabilization process at these locales.

"In general, the pipeline right-of-way is approaching a relatively stable state, due primarily to the success of IPL's revegetation and stabilization efforts. However, continued surveillance is required to ensure stability is achieved and maintained. This need may be met by the weekly monitoring flights which will be conducted by IPL during the operational life of the pipeline.

"In addition to summarizing the four-year watercrossing monitoring program, the results of this program as well as those of studies conducted by IPL, Fisheries and Oceans Canada, and Young (1986) during the construction and initial operating stages of the pipeline are discussed [in] the context of commonly voiced concerns regarding pipeline construction in northern environments. In particular, the recommendations of the Berger (1987) Inquiry and the conclusion of the Mackenzie Environmental Monitoring Project (Indian and Northern Affairs Canada et al. 1986) are considered in light of these monitoring results.

"Undoubtedly the most common aquatic concerns raised regarding pipeline construction and operation are the affects of increased suspended sediment concentrations and the impacts of sedimentation of aquatic habitats. This issue is discussed from two perspectives, the first of which involves instream construction activities while the second considers impacts resulting from perennial instability at watercrossings.

"In regard to the increase in suspended sediment concentrations during pipeline construction activities, the results of studies at the Hodgson Creek crossing were noteworthy. Winter instream construction activities upstream of an overwintering area occupied by juvenile Arctic grayling did not apparently result in any fish mortality, nor was any downstream avoidance behaviour detected in response to increased suspended sediment levels during instream construction activities (G. McKinnon, pers. comm.). Overwintering fish, and in particular species such as Arctic grayling which have been reported to be very sensitive to increases in suspended sediments, were previously considered to require a high degree of protection during this life stage. The second noteworthy result of studies at the Hodgson Creek crossing was the findings of Young (1986). This author determined winter instream construction activity actually minimized impacts on the benthic invertebrate community in relation to that which would have resulted from instream construction during the open-water seasons. This was attributed to a reduced sensitivity of the benthic community to elevated suspended sediment concentrations during the winter months, and the relative inactivity of benthic invertebrates during the period of ice cover. These results, as well as those of other studies involving increased suspended sediment loads are evaluated, and it is proposed that the life stages of the fish fauna which now appear to require primary protection during instream construction activities are the spawning and egg incubation stages.

"The results of studies investigating sedimentation from instream construction activities are reviewed, and it is concluded that the zone of primary concern in this context extends less than 1000 m downstream of pipeline construction activities. The optimal period for installing pipelines across northern watercourses appears to be the winter months, when most smaller drainages are frozen to the substrate. This would not apply to waterbodies which support fall spawning activities. The results of the post-construction surveillance program supports the contention that virtually all introduced sediments are scoured from the watercourse during the first spring freshet.

"The consequences of perennial sediment introduction at watercrossings is viewed in a completely different context, and is acknowledged to have the potential to cause major negative impacts on the aquatic resources. This concern has been recognized by IPL, as reflected in this four-year post-construction monitoring program, and the successful restoration and maintenance programs undertaken.

"Other monitoring studies on the Norman Wells to Zama Pipeline included a wide variety of water quality sampling programs. These investigations revealed that pipeline construction (including instream blasting) and operation did not have adverse effects on water quality (in particular dissolved oxygen levels, temperature or potability), with the obvious exception of suspended sediment concentrations and turbidity. An investigation was also conducted to determine potential impacts of pipeline construction and operation on the discharge regime of Hodgson Creek; no alteration in streamflow characteristics was detected, nor was there any indication of ice-bulb formation around the buried pipe (G. McKinnon, pers. comm.). Finally, the results of a relatively recent study are reported which raises questions regarding the guidelines provided for the instream use of explosives during pipeline construction.

"The three major conclusions of the Mackenzie Environmental Monitoring Project (Indian and Northern Affairs Canada et al. 1986), in reference to the topic of affects of linear corridors on the number, distributions and quality of fish, and fishing success are evaluated in light of the experience gained with the Norman Wells to Zama Oil Pipeline. The first conclusion was that fishing success will be affected, although such affects will be localized and of minor significance. There has been no indication of a reduction in fishing success in waterbodies affected by this pipeline to the knowledge of the author. The second conclusion was that linear corridor development would not likely have a significant affect on fish size, which appears to be correct in the case of the Norman Wells to Zama Oil Pipeline. The third and possibly the most significant conclusion was that linear corridors will affect the number and distribution of fish, which is a consequence that could be minimized by careful route selection and design, the development of appropriate mitigatory measures, on-site supervision during the construction stage of the project, and normal post-construction monitoring and maintenance activities. It is concluded that these precautionary measures are reasonable, and as IPL successfully followed these procedures, it is understandable that there has not been any indication to date of numbers or distributions of fish which have been affected by the construction and operation of the Norman Wells to Zama Oil Pipeline.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This study is of direct relevance to Hypothesis 16 which is concerned with the effect of linear developments (especially pipelines), because it is a monitoring study of an actual development. There are still relatively few case history studies of the effect of northern developments.

MEMP PROJECT OVERVIEW NO. 16-11

TITLE:	Water quality monitoring in relation to 1984 pipeline construction.
PRINCIPAL INVESTIGATOR:	Interprovincial Pipeline (NW) Ltd.
AFFILIATION:	Interprovincial Pipeline (NW) Ltd.
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1984
RELEVANT MEMP HYPOTHESIS:	No.'s 16 and 15

BRIEF PROJECT DESCRIPTION

Interprovincial Pipelines (NW) Ltd. undertook water quality monitoring in relation to pipeline construction on twenty-one watercourses in 1984. Several water potability parameters were monitored during construction in Mackenzie River, Great Bear River and Bosworth Creek which are all used as municipal water sources. IPL identified no negative impacts from these analyses.

Water quality was monitored to determine the impacts of pipeline construction on fisheries habitat potential at eighteen watercourses during winter 1984. Twelve of these watercourses had free flowing water in the vicinity of the crossing. Five of these were found to have water conditions suitable to sustain fisheries in the vicinity of the pipeline. Specifically, Vermillion Creek, Big Smith Creek, River Between Two Mountains, Willowlake River and Trail River had free flowing water and dissolved oxygen concentrations above 5 mg L^{-1} which is considered the lower limit for sustaining most freshwater fish. A continuation of free water flow and high concentrations of dissolved oxygen immediately downstream of these crossings indicates that construction did not impair these habitat criteria.

Impact monitoring in the Mackenzie River determined that direct mortality of fish as a result of an instream explosion was negligible.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of monitoring of the Interprovincial Pipeline construction across waterways further clarifies the extent and duration of expected and unexpected effects on the flow regime, water quality and adjacent aquatic habitat. It also provides useful information on the effectiveness of mitigation measures. The information is pertinent to Links 1, 2, 3, 4, 6, and 7 of Hypothesis 16.

MEMP PROJECT OVERVIEW NO. 16-12

TITLE: Water quality monitoring in relation to 1985 pipeline construction and operation.

PRINCIPAL INVESTIGATOR: Interprovincial Pipeline (NW) Ltd.

AFFILIATION: Interprovincial Pipeline (NW) Ltd.

FUNDING SOURCE: Interprovincial Pipeline (NW) Ltd.

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No.'s 16 and 15

BRIEF PROJECT DESCRIPTION

Interprovincial Pipeline (NW) Ltd. undertook water quality monitoring in relation to pipeline construction and operation on twenty watercourses in 1985. Several physical and chemical water quality parameters were monitored at Mackenzie River, Great Bear River and Bosworth Creek pipeline crossings which are all used as municipal water sources. These analyses, according to IPL, indicate that pipeline construction and operation has not affected these water courses negatively.

Water samples were taken from Willowlake River and analysed for microbial populations. The results of the analyses show that problems with microbial water quality are not related to pipeline construction or operation.

Water quality was monitored at sixteen other watercourses to determine the impacts of construction on fisheries habitat potential. Thirteen of these watercourses were found to have free water flow in the vicinity of the crossing at the time of construction. IPL concluded that a continuation of free water flow and high concentrations of dissolved oxygen immediately downstream of these crossing indicates that construction did not impair these habitat criteria.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of monitoring of the Interprovincial Pipeline construction across waterways further clarifies the extent and duration of expected and unexpected effects on the flow regime, water quality and adjacent aquatic habitat. It also provides useful information on the effectiveness of mitigation measures. The information is pertinent to Links 1, 2, 3, 4, 6, and 7 of Hypothesis 16.

MEMP PROJECT OVERVIEW NO. 16-13

TITLE:	Norman Wells Pipeline Project 1985 report on monitoring of construction and operation.
PRINCIPAL INVESTIGATOR:	Interprovincial Pipeline (NW) Ltd.
AFFILIATION:	Interprovincial Pipeline (NW) Ltd.
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No.'s 16 and 15

BRIEF PROJECT DESCRIPTION

In 1985, Interprovincial Pipeline (NW) Ltd. undertook monitoring to determine the effects of the pipeline construction and operation on the environment, the condition of the right-of-way including river crossings and slopes, and the condition of the pipeline. No conditions developed in 1985 that would indicate that the pipeline realized excessive stress. Thaw settlement has resulted in maximum calibrated strain values of less than 50 percent of design strain.

No major slope instability problems occurred during 1985 although some minor slumping occurred at a few locations. Once corrected, no further problems are anticipated at these slopes. The slope indicator at Christina Creek revealed continued movement although small in magnitude. This location is to be studied further during winter, 1986.

IPL concluded that construction and operation activities did not cause water quality conditions which would affect water potability for domestic use or fisheries habitat in the vicinity of the crossing. At certain locations, insufficient bank armouring and subsidence of ditch line were noted. IPL feels appropriate bank protection and backfill of approach ditch line to be completed in winter 1986, will enhance stability.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of monitoring of the Interprovincial Pipeline construction across waterways further clarifies the extent and duration of expected and unexpected effects on the flow regime, water quality and adjacent aquatic habitat. It also provides useful information on the effectiveness of mitigation measures. The information is pertinent to Links 1, 2, 3, 4, 6, and 7 of Hypothesis 16.

MEMP PROJECT OVERVIEW NO. 16-14

TITLE:	Norman Wells Pipeline Project 1986 report on monitoring of construction and operation.
PRINCIPAL INVESTIGATOR:	Interprovincial Pipeline (NW) Ltd.
AFFILIATION:	Interprovincial Pipeline (NW) Ltd.
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 16 and 15

BRIEF PROJECT DESCRIPTION

In 1986, Interprovincial Pipeline (NW) Ltd. undertook monitoring to determine the effects of the pipeline construction and operation on the environment, the condition of the right-of-way including river crossings and slopes, and the condition of the pipeline. During 1986, apparent differential settlement of the pipe was observed, necessitating sustained effort to observe changes.

No major slope instability problems occurred during 1986 although some minor slumping occurred a few locations. IPL feel once they are corrected, no further problems are anticipated at these slope. The slope indicator at Christina Creek revealed continued movement although small in magnitude. IPL says this location will be studied further again in 1987. At certain water crossings, insufficient bank armouring and subsidence of ditch line were noted. IPL plans to remedy the problem by appropriate bank protection and backfill of approach ditch line during winter 1987, which they feel will enhance stability.

Significant erosion was noted at Hodgson Creek as a result of high water levels during spring freshet and summer rain storms. Sedimentation downstream of watercrossings resulting from pipeline construction and operation was virtually nonexistent along the pipeline route during 1986. In a single instance, at Jungle Ridge Creek, sedimentation was attributed to the improper orientation of a crossdrainage berm. IPL said the berm would be repaired prior to the 1987 spring thaw.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of monitoring of the Interprovincial Pipeline construction across waterways further clarifies the extent and duration of expected and unexpected effects on the flow regime, water quality and adjacent aquatic habitat. It also provides useful information on the effectiveness of mitigation measures. The information is pertinent to Links 1, 2, 3, 4, 6, and 7 of Hypothesis 16.

MEMP PROJECT OVERVIEW NO. 16-15

TITLE:	Norman Wells Pipeline Project 1987 Report on monitoring of construction and operation.
PRINCIPAL INVESTIGATOR:	Interprovincial Pipeline (NW) Ltd.
AFFILIATION:	Interprovincial Pipeline (NW) Ltd.
FUNDING SOURCE:	Interprovincial Pipeline (NW) Ltd.
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 16 and 15

BRIEF PROJECT DESCRIPTION

In 1987, Interprovincial Pipelines (NW) Ltd. undertook monitoring to determine the effects of the pipeline construction and operation on the environment, the condition of the right-of-way including river crossings and slopes, and the condition of the pipeline. Surveys to detect differential settlement of the pipe were undertaken in September, 1987. IPL concluded the collected data indicated that settlement over the past year was insignificant and calculated strain values were within design parameters. Frost heave data also showed that related pipe stress had been minor.

IPL noted no new slope instability problems during 1987. The slope indicator at Christina Creek revealed continued movement although relatively small in magnitude. IPL plans to continue studies there in 1988.

Insufficient bank armouring and subsidence at ditch line were noted at few watercourse crossings. IPL plans appropriate bank protection for winter, 1988 to enhance stability at these locations. IPL also plans to lower the pipe elevations throughout the alluvial fan at Hodgson Creek in winter 1988. IPL concludes that after four years of aquatic monitoring there appears to have been minimal impacts of the pipeline construction and operation on the aquatic systems.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The results of monitoring of the Interprovincial pipeline construction across waterways further clarifies the extent and duration of expected and unexpected effects on the flow regime, water quality and adjacent aquatic habitat. It also provides useful information on the effectiveness of mitigation measures. The information is pertinent to Links, 1, 2, 3, 4, 6, and 7 of Hypothesis 16.

MEMP PROJECT OVERVIEW NO 16-16

TITLE: Deep scour holes on the bed of Mackenzie Delta channels, N.W.T.

PRINCIPAL INVESTIGATOR: M.F. Lapointe

AFFILIATION: National Hydrology Research Institute, Environment Canada

FUNDING SOURCE: Inland Waters Directorate

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No. 16

BRIEF PROJECT DESCRIPTION

As discussed in previous reports by Lapointe (1984 and 1985), unusually deep scour holes occur within the distributory channels of the Mackenzie Delta. The shape, location and distribution of these holes, some 5 to 6 times the average bankfull channel depth, are described. Many holes were found to be located at river bends and in other areas where hydraulic forces may prevent settling of suspended fine sands and silts, and may possibly erode loose mud from the river bed. However, some tight river bends do not contain deep scour holes and, conversely, some deep scour holes occur in areas where little concentration of hydraulic forces is expected. The reason for this variability is largely unknown. Factors likely to be important include differences in texture, degree of consolidation, segregated-ice content, etc. The author recommends that additional data on subsurface river bed material characteristics are required in order to understand the origin of these unusually deep scour holes.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis 16, Links 1 and 2 suggest that construction-related activities may alter channel geometry at specific locations and result in increased rates of sediment production. The results of Lapointe's 1986 study suggest that construction activities (such as river excavations to install a buried pipeline) could expose materials which are susceptible to erosion. This possibility provides additional support for the validity of Links 1 and 2.

MEMP PROJECT OVERVIEW NO. 16-17

TITLE:	Mackenzie Delta channel dynamics: miscellaneous data.
PRINCIPAL INVESTIGATOR:	M.F. Lapointe
AFFILIATION:	National Hydrology Research Institute, Environment Canada
FUNDING SOURCE:	Environment Canada
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 16

BRIEF PROJECT DESCRIPTION

This report documents rates of channel shifting on the Mackenzie Delta and indicates that average annual rates of bank recession can be as high as 10.7 m yr^{-1}. Bed material texture was investigated along a 130 km reach of East Channel and confirmed a previously suspected downstream decrease in sand content.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Hypothesis No. 16, Links 1 and 2 suggest that construction of a linear corridor may result in increased rates of sediment production or changes in channel geometry. Link 6 suggests that increased sediment production may result in changes in bed material size. Lapointe's 1986 studies indicate that substantial river training works may be required to control channel shiftings in the vicinity of proposed development sites. These activities may, in the long term, locally decrease rates of sediment production and alter channel geometry.

The data collected by Lapointe indicate that bed material size may undergo substantial seasonal variation. Any project-related monitoring of bed material size must take this variability into consideration during the design of the sampling program.

MEMP PROJECT OVERVIEW NO. 16-18

TITLE:	Assessment of problems related to the source, transfer and fate of sediment along the Mackenzie River, N.W.T.
PRINCIPAL INVESTIGATOR:	M. Carson
AFFILIATION:	M. Carson and Associates
FUNDING SOURCE:	Inland Waters Directorate
EXPECTED COMPLETION DATE:	1988
RELEVANT MEMP HYPOTHESIS:	No.'s 14, 15 and 16

BRIEF PROJECT DESCRIPTION

This report investigates sediment and sediment related issues on the Mackenzie River between Great Slave Lake and Point Separation. In addition to looking at the volumes of sediment transported, the author investigates the absorbtion of chemical pollutants in suspended and bed material sediment. Data deficiencies are identified and recommendations on appropriate studies are presented.

RELATIONSHIP AND RELEVANCE THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report provides estimates of rates of natural sediment transport upstream of Point Separation and an analysis of the role that suspended and bed material sediments may play in transporting and concentrating absorbed pollutants or other chemical. This information will allow a better definition of any proposed sampling program to determine how petroleum development may affect these processes within the Mackenzie Delta.

MEMP PROJECT OVERVIEW NO. 16-19

TITLE:	Sediment transfer along Mackenzie River: a feasibility study.
PRINCIPAL INVESTIGATOR:	M. Church, M. Miles and K. Rood
AFFILIATION:	M. Miles and Associates Ltd.
FUNDING SOURCE:	Inland Waters Directorate
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 16 and 4

BRIEF PROJECT DESCRIPTION

This report examines the feasibility of using temporal changes in channel bathymetry and river plan form as a basis for estimating rates of bed material transport. Calculations from data taken near Norman Wells suggest average annual bed material transport is on the order of 1.0×10^6 tonnes yr^{-1} which is 1.1% of the total suspended sediment load calculated by Lewis (in progress) for the gauging station above Arctic Red River. Similar methods were also employed to investigate the rate of formation and erosion of riparian habitats in the vicinity of Norman Wells. The results of this study indicate that unusually high rates of habitat development occurred during the period between air photographs taken in 1951 and 1962. It is postulated that this gain in riparian area may have resulted from the unusually small annual flood discharges which occurred in the period 1943-1962. Statistical tests indicate there is a 95 to 99% probability that a significant shift in hydrological regime has occurred at the Norman Wells stream gauging station with the post-1962 average annual maximum daily flow (24,080 $m^3\ S^{-1}$) being 23% larger than the average value recorded in the period 1943-1962 (19,580 $m^3\ S^{-1}$).

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Rates of naturally occurring sediment transport in the Mackenzie Delta are not well known. Using the techniques developed by Church, Miles and Rood (1987), and the rates of channel shifting documented by Lapointe (1986), it may be possible to assess the contribution to total sediment transport resulting from channel shiftings within the Mackenzie Delta. This information would provide a basis for evaluating the potential effects of construction-related changes in sediment availability.

The apparent change in hydrologic regime at Norman Wells may extend as far north as the Mackenzie Delta. Any assessment of contemporary water levels, or the evaluation of how these may be affected by construction activities, must therefore include an analysis of the effects of potential historical changes in hydrologic regime. Similarly, present day riparian habitat characteristics may be different from those which have occurred during earlier periods of this century when river discharge may have been smaller.

HYPOTHESIS NO. 17

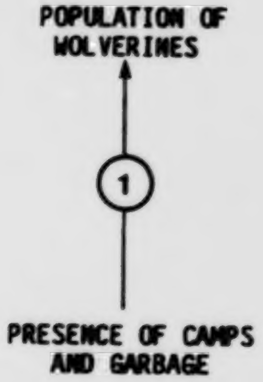
WOLVERINES THAT ARE ATTRACTED TO CAMPS AND GARBAGE WILL BE KILLED AS NUISANCE ANIMALS, THUS REDUCING THE POPULATION

For Hypothesis No. 17, the valued ecosystem component was wolverine. Conclusions reached were that this hypothesis was unlikely to be valid. It was recommended that possible effects could be mitigated through live trapping and reallocation of nuisance animals.

No relevant projects were identified for this hypothesis.

HYPOTHESIS NO. 17

Wolverines attracted to camps and garbage will be killed as nuisance animals, thus reducing the population


POPULATION OF WOLVERINES
1
PRESENCE OF CAMPS AND GARBAGE

LINKAGES

Link 1: Wolverines attracted to camps and garbage will be killed as nuisance animals, thus reducing the population.

HYPOTHESIS NO. 18

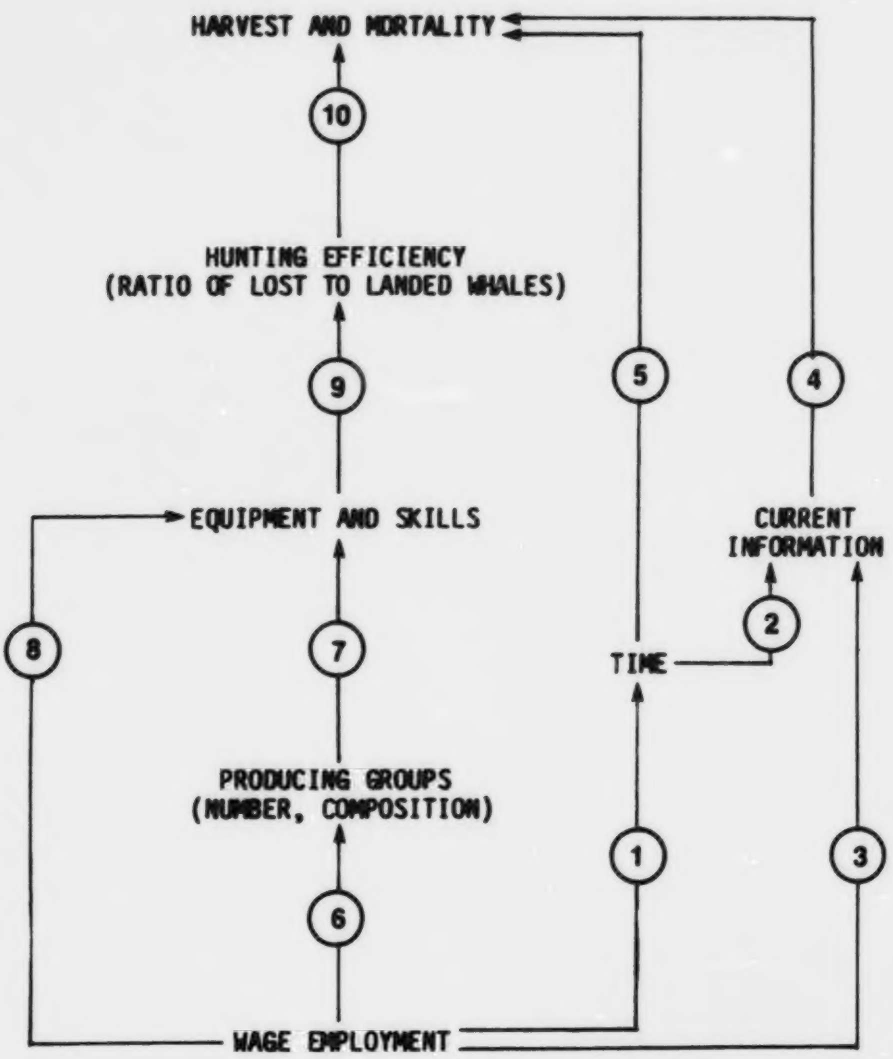
WAGE EMPLOYMENT WILL CHANGE THE HARVEST OF WHITE WHALES

For Hypothesis No. 18, the valued ecosystem component was the white whale. Conclusions reached were that this hypothesis was possibly valid in terms of harvest composition, but probably invalid in terms of level of harvest. Continued monitoring of white whale harvests was recommended.

The following material covers nine project overviews relevant to this hypothesis.

HYPOTHESIS NO. 18

Wage employment will change the harvest of white whales


HARVEST AND MORTALITY
10
HUNTING EFFICIENCY (RATIO OF LOST TO LANDED WHALES)
9
5
4
EQUIPMENT AND SKILLS
CURRENT INFORMATION
8
7
2
TIME
PRODUCING GROUPS (NUMBER, COMPOSITION)
1
3
6
WAGE EMPLOYMENT

LINKAGES

Link 1: Wage employment of Mackenzie Delta residents will result in less time available for hunting and thereby reduce native hunting effort.

Link 2: Reduced hunting effort will decrease the amount of new information obtained each year concerning the distribution and availability of white whales.

Link 3: Wage employment will affect the current level of information by changing the travelling routes and living areas of natives.

Link 4: A change in the current level of information will affect the harvest.

Link 5: Reduced hunting effort will decrease the number of whales taken and/or change the age/sex composition of the harvest.

Link 6: Wage employment will alter the number and/or the composition of harvesting groups.

Link 7: A change in the number and/or composition of harvesting groups will decrease the general level of skills and change the quality of equipment used by hunters.

Link 8: Wage employment will change the quality of th equipment used by hunters.

Link 9: Less skillful hunters and a change in the quality of equipment used will reduce hunter efficiency (i.e., increase the ratio of lost to landed whales).

Link 10: An increase in the ratio of lost to landed whales will increase white whale mortality.

MEMP PROJECT OVERVIEW NO. 18-1

TITLE:	The effects of rotational wage employment on families and workers in the Beaufort - Mackenzie Delta area.
PRINCIPAL INVESTIGATOR:	Anonymous
AFFILIATION:	Department of Social Services, Government of the N.W.T.
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 18 and 22

BRIEF PROJECT DESCRIPTION

Project objectives were: 1) to determine the effects of work rotation on families and workers in the Beaufort; to assess the effects; and 2) to devise appropriate solutions. The project workplan included assembling an annotated bibliography on rotational wage employment and resource development; a preliminary identification of social indicators to effectively measure and monitor the impacts of rotational wage employment on workers and their families; and gathering historical oil and gas employment data for nine Beaufort communities for the purpose of a preliminary investigation into participation in rotational oil and gas employment.

The annotated bibliography summarizes the advantages and disadvantages of rotational wage employment as found in the literature. On the advantage side, rotational wage employment provides workers with frequent large blocks of time, allowing for hunting and other resource harvesting excursions. Rotational wage employment also provides income for traditional harvesting activities. The disadvantages are cited as: less time to spend hunting, trapping and fishing; an increase in wage incomes and break down in traditional modes of community sharing and support; and loss of traditional skills due to integration into the job market.

The report concludes with a set of recommendations. Of major importance is the recommendation to continue research on the effects of rotational wage employment on workers and families in the Beaufort/Mackenzie Delta including primary research and community consultation. The research team further recognized the need to include fur and game harvest indicators in future measuring/monitoring of the effects of rotational employment. It is stated that past research leads to the conclusion that there was no significant conflict between rotational employment and traditional economic activities.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The report is, in effect, an annotated bibliography of reports relating to the effects of rotational employment on workers and families of the Mackenzie Delta/Beaufort Sea area. The report's significance to MEMP hypotheses 18 and

22 is limited in that it lists selected advantages and disadvantages of rotational wage employment on land and offshore resource harvesting activities.

The report identified indicators for monitoring and evaluating the impacts of rotational wage employment on traditional hunting and trapping activities.

MEMP PROJECT OVERVIEW NO. 18-2

TITLE:	Annual Canada benefits submissions.
PRINCIPAL INVESTIGATOR:	D. O'Rourke
AFFILIATION:	Canadian Oil and Gas Lands Administration
FUNDING SOURCE:	COGLA
COMPLETION DATE:	Ongoing
RELEVANT MEMP HYPOTHESIS:	No.'s 18 and 22

BRIEF PROJECT DESCRIPTION

The report is an annual compilation of workers recruited by industry to hydrocarbon development projects. The report summarizes recruitment numbers, and work duration by northern communities. It does not differentiate between native and non-native workers.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Annual data collection by COGLA provides a database covering recruitment of community workers into the northern oil and gas industry. The application of the data to Hypotheses 18 and 22 serves to identify levels of wage employment in selected Mackenzie Delta communities each year related to the oil and gas industry. The data base combined with harvest data can have significance to the ongoing monitoring and evaluation of harvesting activities in the Mackenzie Delta. However, the usefulness of the data from this study is limited because of the lack of differentiation between native and non-native workers.

MEMP PROJECT OVERVIEW NO. 18-3

TITLE: Harvest statistics: Mackenzie Estuary beluga hunt 1985, 1986, 1987.

PRINCIPAL INVESTIGATOR: Anonymous

AFFILIATION: Department of Fisheries and Oceans

FUNDING SOURCE: Department of Fisheries and Oceans

COMPLETION DATE: On-going

RELEVANT MEMP HYPOTHESIS: No.'s 18 and 19

BRIEF PROJECT DESCRIPTION

White whale harvest data are presented for each of 1985, 1986 and 1987. Data are standardized and presented for four geographic areas in the Mackenzie Estuary. The total number of whales struck, lost and landed are reported based on harvester interviews, monitoring records, and estimates of whales lost and not recorded. Sex distribution of the landed harvest, and kill statistics are disaggregated for four geographic areas by struck, landed and lost.

Comparing the totals for each of the years, harvesting activity increased in all categories (struck, landed and lost) in 1986; however, 1987 totals showed declines.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The monitoring reports provide an ongoing standardized information base of white whale harvest in the Mackenzie Estuary. The information base could be used in further study of the relationships of harvest to vessel traffic, and harvest to wage employment outlined in Hypothesis 18 and 19.

MEMP PROJECT OVERVIEW NO. 18-4

TITLE:	Harvest study, Inuvialuit Game Council 1987/88.
PRINCIPAL INVESTIGATOR:	M. Fabijan
AFFILIATION:	Joint Secretariat
FUNDING SOURCE:	Inuvialuit Final Agreement Implementation Funding Sponsored by Department of Fisheries and Oceans, Canadian Wildlife Service, Government Northwest Territories, in conjunction with the Inuvialuit Game Council and local Hunters and Trappers Committees.
EXPECTED COMPLETION DATE:	On-going
RELEVANT MEMP HYPOTHESIS:	No.'s 18 to 25

BRIEF PROJECT DESCRIPTION

The harvest studies commenced in April 1987 and the first report should be published in April 1988. Data collection is focusing on 69 species of birds, marine mammals and terrestrial animals. The data will indicate harvest location, date, quantity, sex and maturity. Data on harvesters may include hunter age, and will determine the number of hunters in each of the Inuvialuit Communities and over the entire region. Subsequently the study will identify hunting, trapping and fishing areas by community and region.

Currently there is no baseline data, however, this process will be on-going for at least 3 years. Under the terms of the Inuvialuit Final Agreement the harvest study should continue beyond the 3 years of the current Implementation Funding Agreements between the Joint Secretariat and sponsoring groups.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Although there are no data published to date, the study will provide a valuable baseline from which to evaluate Hypotheses 18 through 25. Study focus in the Inuvialuit Final Agreement area should provide data on at least the three Mackenzie Delta communities of Tuktoyaktuk, Inuvik and Aklavik.

MEMP PROJECT OVERVIEW NO. 18-5

TITLE:	Identification of impact indicators for renewable resource harvesting.
PRINCIPAL INVESTIGATORS:	D. Delancey and P.J. Usher
AFFILIATION:	Fee-Yee Consulting Ltd. and P.J. Usher Consulting Services
FUNDING SOURCE:	Environmental Planning and Assessment, Department of Renewable Resources, Government of the N.W.T.
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 18-25

BRIEF PROJECT DESCRIPTION

The purpose of the study was to review and evaluate the impact hypotheses generated by MEMP workshops and to ensure, to the extent possible, that they are both accurate and thorough; to propose working definitions for such terms as "harvest", "indicator", "harvester", "effort"; and to propose an initial set of indicators which can be used to assess and monitor impacts of developments on renewable resource harvesting. Study methods included an evaluation of the hypotheses based on a literature review, a harvesters' workshop to evaluate the hypotheses, and a further refinement of hypotheses at the final MEMP workshop.

The literature review concluded that useful renewable resource harvesting indicators must realistically reflect harvesting as a social system; must be amenable to repetitive measurement; should be generated from, and causally related to, a given hypothesis; and must be agreed upon by both researcher and harvester. From the harvesters' workshop and further MEMP sessions, it became clear that the hypotheses were neither final nor universally applicable, and would be subject to considerable change and revision.

The study identifies and focuses on key variables, and priorizes indicators associated with these variables. Two essential criteria for establishing priorities for monitoring are stated as: 1) the accuracy with which the phenomenon can be measured and its reliability as an indicator of any particular variable; and 2) the strength of that variable as a line in a causal chain of events. Based on these considerations, the authors proposed a ranking of indicators:

High Priority

- abundance, distribution, quality
- time, gear, location
- costs
- catch
- amount of employment, duration, location, flexibility
- non-local harvesters
- project activities
- roads, seismic lines, barriers

Other

- mutual aid and sharing
- skills
- income
- non-retrieval, disposition

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report was completed in conjunction with the original MEMP process and in effect, builds on that process. It provides a guideline for the Department of Renewable Resources, Government of the Northwest Territories for future harvest study. As stated, the hypotheses relating to hydrocarbon development and harvesting are not final or universally applicable, and would be subject to considerable change and revision. The key variables are identified and priorized and should be relevant to further harvest monitoring and research.

It is notable that the Department of Renewable Resources, Government of the Northwest Territories is currently developing a framework for harvest studies.

MEMP PROJECT OVERVIEW NO. 18-6

TITLE:	A review of renewable resource impacts and mitigation measures related to northern hydrocarbon development.
PRINCIPAL INVESTIGATORS:	Environmental Systems Group; Delcan, De Leuw Cather, Canada Ltd.
AFFILIATION:	Policy and Planning Division, Department of Renewable Resources, Government of the Northwest Territories
FUNDING SOURCE:	Department of Renewable Resources
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 18-25

BRIEF PROJECT DESCRIPTION

The objectives of the study were to classify and describe common, renewable resource impacts and corresponding mitigative measures associated with northern hydrocarbon development activities; and to identify the role of mitigation and the effectiveness of mitigative measures in reducing impact identified as being of regional significance. A review of selected literature relating to northern hydrocarbon development, and associated environmental impacts and mitigative measures, was undertaken to satisfy study requirements. The impacts and mitigative measures focus primarily on wildlife and related habitat.

The report develops a matrix of renewable resource and harvesting impacts related to northern hydrocarbon development. The matrix displays major industrial activities at three phases of development (exploration, production and abandonment) against more common environmental perturbations and renewable resource impact indicators.

The report outlines the role of mitigation in environmental assessment. It states that the proper implementation of mitigative measures prescribed is perhaps the single most important factor in effective mitigation. However, there is often insufficient baseline environmental information or incomplete records of construction from which to adequately evaluate the effectiveness of mitigative measures.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Of particular relevance in this study is the identification of major concerns and common mitigation for resource harvesting at the various stages of an industrial development. The concerns are further addressed by MEMP hypotheses where resource harvesting is of consequence. The Department of Renewable Resources has, through this work, a framework for addressing environmental concerns associated with industrial activity and attendant impacts on resource harvesting. The application of, and compliance with the range of common mitigative measures to hydrocarbon activity can be further refined and linked to the hypotheses.

MEMP PROJECT OVERVIEW NO. 18-7

TITLE:	The Dene experience with the Norman Wells Pipeline Project mid-term evaluation, September 1985.
PRINCIPAL INVESTIGATOR:	Anonymous
AFFILIATION:	Dene Nation
FUNDING SOURCE:	Government of Canada Contribution Agreement with Dene Nation for the Delivery of a Planning Support and Monitoring Program
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No.'s 18-25

BRIEF PROJECT DESCRIPTION

The study evaluates the Norman Wells Project impact assessment and impact management against the original Dene terms of conditional acceptance of the Norman Wells Project. The original Dene terms outlined the Dene involvement in ownership, management, and resources required to mitigate identified impacts of the Norman Wells Project.

The mid-term evaluation reviews Norman Wells Project performance with respect to socio-economic and environmental impact and management. The issues identify basic deficiencies in impact identification, assessment, management and monitoring processes to September 1985 (near completion of project construction).

The report concludes that meaningful decision making on regulatory management and monitoring of major industrial development projects is not possible under the present system. It reiterates that an aboriginal rights settlement should be in place prior to another such project.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The recommendations outlined in the report provide a Dene framework for changing the regulatory review and monitoring processes of hydrocarbon development in the Mackenzie Valley. The framework includes a requirement for baseline data collection for on-going monitoring purposes, and public evaluation of project approval, decision making, management and regulation processes; and also requires that evaluation be a forum for communities to assess their own impacts.

Of relevance to the hypotheses is the implication of local Dene involvement in establishing terms of reference for, and involvement in managing socio-economic and environmental monitoring and evaluation exercises/studies. This should ensure that local community knowledge is not overlooked in the monitoring and evaluation processes.

MEMP PROJECT OVERVIEW NO. 18-8

TITLE:	Canadian Oil and Gas Lands Administration, call for proposals Number 86 N.W.T. - 1 Schedule 11: Community participation and local and northern benefits, Chevron Canada Resources Ltd.
PRINCIPAL INVESTIGATOR:	Anonymous
AFFILIATION:	Chevron Canada
FUNDING SOURCE:	Chevron Canada
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 18-25

BRIEF PROJECT DESCRIPTION

The Chevron news release outlines the compensation and environmental monitoring plans submitted by the company to satisfy conditions of community participation and local and northern benefits for the Canadian Oil and Gas Lands Administration in their exploration program in the Fort Good Hope/Colville Lake area.

The Chevron compensation plan and environmental monitoring plans outline the consultative, implementation and funding processes for assessing potential impacts from exploration programs, establishing baseline data with respect to land use and average harvest level, design of a monitoring and evaluation study of exploration activity, and terms and conditions of compensation for affected harvesters. A compensation subcommittee of the joint Chevron/Fort Good Hope management committee would evaluate and recommend to the management committee acceptance, rejection or variance of a claim. Similarly, the Environmental Subcommittee would report its evaluation and recommendations to the Operations Management Committee.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The report outlines a framework for hydrocarbon resource exploration in and around Fort Good Hope and Colville Lake. The framework is relevant to the hypotheses in that it is a new approach to assessing, monitoring and evaluating socio-economic and environmental impacts of industrial development in the Mackenzie Valley. The basis of change is the collaboration of industry and the communities of Fort Good Hope and Colville Lake as partners in responsibility for impact management. Since the process is beginning, the application to specific linkages in the harvesting hypotheses cannot be made; however, as exploration continues there should be a further basis to test the harvesting hypotheses.

MEMP PROJECT OVERVIEW NO. 18-9

TITLE: Historical harvest summary for general hunting licence holders in the Fort Smith and Inuvik regions, Northwest Territories from 1931/32 through 1984/85.

PRINCIPAL INVESTIGATOR: Anonymous

AFFILIATION: Department of Renewable Resources, Government of the Northwest Territories

FUNDING SOURCE: N.W.T. Government

COMPLETION DATE: 1986

RELEVANT MEMP HYPOTHESIS: No.'s 18-25

BRIEF PROJECT DESCRIPTION

The report summarizes the available harvest records of big game species taken by Mackenzie Valley and Delta area general hunting licence holders from 1931/32 to 1984/85. Data were obtained from primary and secondary reports. The data were compiled to provide background information for upcoming harvest studies.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Although the report indicates that the data would not be reliable for establishing absolute harvest figures for use in determining compensation from industrial development, the economic value of a resource, or basic needs levels in land claims negotiation, the data provide general historical trends. The reliability of the data does present some question as to their usefulness in a rigorous scientific examination of causal linkages in the hypotheses.

MEMP PROJECT OVERVIEW NO. 18-10

TITLE: A downstream perspective: Dene concerns with the environmental assessment, monitoring and surveillance of the Norman Wells Project with particular reference to fish and water quality.

PRINCIPAL INVESTIGATOR: D. Delancey

AFFILIATION: Fee-Yee Consulting Ltd.

FUNDING SOURCE: Government of Canada through a contribution agreement with Dene Nation for the Delivery of Planning Support and Monitoring Program

COMPLETION DATE: 1985

RELEVANT MEMP HYPOTHESIS: No.'s 13-15

BRIEF PROJECT OVERVIEW

The report addresses concerns of Dene with respect to water quality and fish relative to the Norman Wells Project. The evaluation of environmental assessment, monitoring and surveillance on the project is from the perspective of traditional resource users and indicates deficiencies in these processes. The report raises fish harvest and management concerns. For example, the lack of baseline data on fish habitat and habitat alteration, fish migration routes, and increased access to fishing in the Mackenzie Valley are identified as areas of concern.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The report is relevant as a framework for the hypotheses relating to the impacts of hydrocarbon activity on fish harvest. It reinforces the fact that local and Dene knowledge should be recognized in project surveillance and monitoring studies.

HYPOTHESIS NO. 19

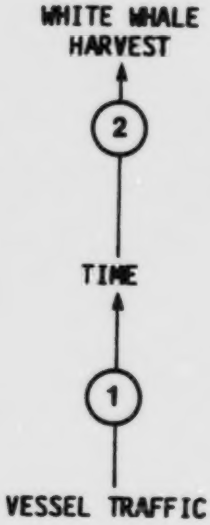
VESSEL TRAFFIC WILL DECREASE THE HARVEST OF WHITE WHALES

For Hypothesis No. 19, the valued ecosystem component was the white whale. Conclusions reached were that this hypothesis was possible but unlikely. Continued monitoring was recommended.

The following material covers one project overview relevant to this hypothesis.

HYPOTHESIS NO. 19

Vessel traffic will decrease the harvest of white whales


WHITE WHALE HARVEST
2
TIME
1
VESSEL TRAFFIC

LINKAGES

Link 1: Vessel traffic will reduce the time available for hunting by directly interfering with hunting activities.

Link 2: Less time available for hunting will result in a decrease in the harvest of white whales.

MEMP PROJECT OVERVIEW NO. 19-1

TITLE:	1986 Arctic industrial activities compilation for the Canadian Beaufort Sea: seismic surveys, vessel movements, aircraft traffic and offshore marine research.
PRINCIPAL INVESTIGATORS:	P. Norton, J.W. McDonald and A. Blyth
AFFILIATION:	PN Research Project and ESL Environmental Sciences Ltd.
FUNDING SOURCE:	DIAND, NOGAP
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No.'s 19 and 24

BRIEF PROJECT OVERVIEW

The study summarizes industrial activity during 1986 in the Beaufort Sea and Mackenzie Delta. Data were compiled for short intervals (10-11 days) between 1 July and 30 September and monthly intervals for June, October, November and December. Data categories were: 1) seismic and sounding; 2) vessel activities; 3) aircraft activities; and 4) research activities.

The report provides a definition of the Main Industrial Zone (M.I.Z.) for 1986 and brief descriptions of each category of industrial activity. Seismic activity is proprietary and was therefore not mapped; while sounding, vessel, aircraft and research categories were mapped for the reporting intervals. The report presents a written and visual temporal and spatial perspective of the categories of industrial activities.

The major concentration of 1986 industrial activities was within the Mackenzie estuary. Movements of vessels during the early open-water season (June and July) were associated with the start-up of island construction and drilling activities and were concentrated within and just north of the Mackenzie estuary. Vessel activity continued in and within close proximity to the estuary through mid-August and then shifted to other areas of the Beaufort. Similarly, aircraft activities were concentrated in and just north of the Mackenzie estuary from June through October.

Standardized data collection makes it possible to compare 1986 and 1985 industrial activities. The main industrial zone was somewhat smaller in 1986, and the intensity of vessel and aircraft movements was greatly diminished.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report is relevant to at least two hypotheses (19 and 24) in terms of measuring the impact of industrial activity on the harvest of marine mammals, fish, birds and animals. The report presents a database and computerized map. Standardized indicators serve to identify movement of major industrial activity during a six-month time frame.

Hypothesis 24 concludes that impacts are possible and that study is required to determine whether they occur and how serious they might be. The original hypothesis suggests the utility of collecting both harvest and land use information to support compensation claims. This report serves to identify industrial land use activity within the Mackenzie estuary, thereby satisfying a condition of Hypothesis 24.

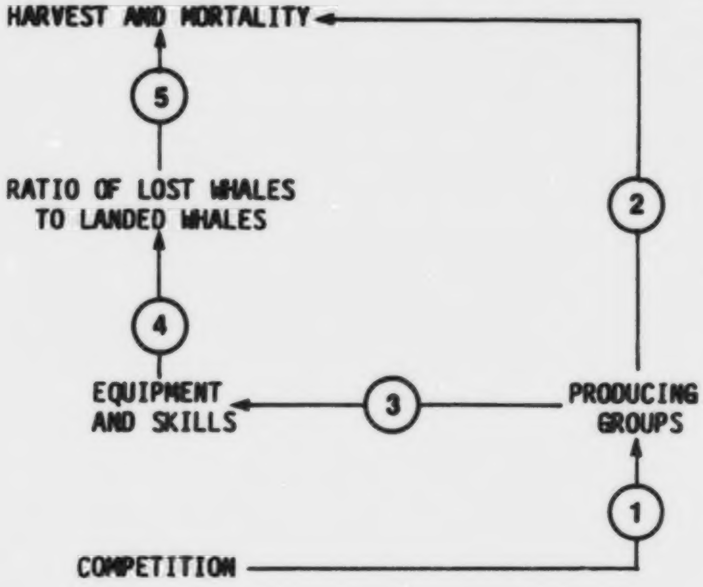
HYPOTHESIS NO. 20

COMPETITION BY NON-LOCALS WILL CHANGE THE NUMBER OF WHITE WHALES LANDED AND INCREASE MORTALITY IN THE POPULATION

For Hypothesis No. 20, the valued ecosystem component was the white whale. Conclusions reached were that this hypothesis was unlikely to be valid and no recommendations were made. No relevant projects were identified for this hypothesis.

HYPOTHESIS NO. 20

Competition by non-locals will change number of white whales landed and increase mortality in the population


HARVEST AND MORTALITY
5
RATIO OF LOST WHALES TO LANDED WHALES
2
4
EQUIPMENT AND SKILLS
3
PRODUCING GROUPS
1
COMPETITION

LINKAGES

Link 1: Competition will increase the number of, and alter the composition of the harvesting groups if both local and non-local hunters are involved in the harvest.

Link 2: An increase in the number of harvesting groups will increase the harvest and mortality of white whales.

Link 3: Inexperienced, non-local hunters will have less skill than local hunters, as well as incomplete or inappropriate equipment.

Link 4: Less skillful and effective hunter, in conjunction with incomplete or inappropriate equipment, will increase the ratio of lost to landed whales.

Link 5: An increase in the ratio of lost to landed whales will cause an increase in white whale mortality.

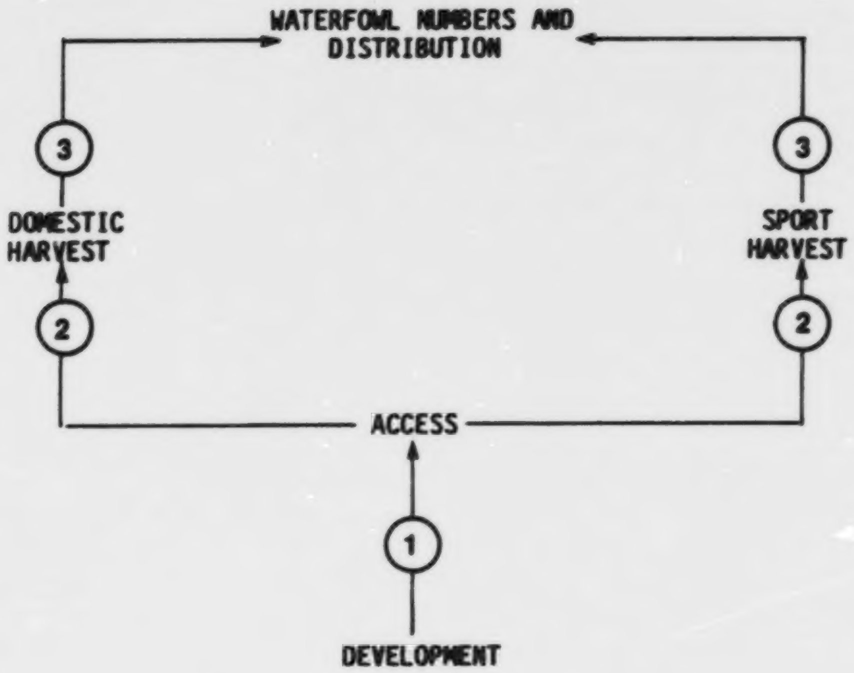
HYPOTHESIS NO. 21

INCREASED OR IMPROVED ACCESS ASSOCIATED WITH HYDROCARBON DEVELOPMENT WILL INCREASE THE HARVEST OF WATERFOWL, WHICH WILL LEAD TO A REDUCTION IN THE NUMBER AND ALTER THE DISTRIBUTION OF WATERFOWL

For Hypothesis No. 21, the valued ecosystem component was waterfowl. Conclusions reached were that this hypothesis was valid but unlikely and so no recommendations were made. No relevant projects were identified for this hypothesis.

HYPOTHESIS NO. 21

Increased or improved access associated with hydrocarbon development will increase the harvest of waterfowl, which will lead to reduction in the number and alter the distribution of waterfowl


WATERFOWL NUMBERS AND DISTRIBUTION
3
3
DOMESTIC HARVEST
SPORT HARVEST
2
2
ACCESS
1
DEVELOPMENT

LINKAGES

Link 1: Hydrocarbon development will result in increased or improved access to areas supporting waterfowl populations.

Link 2; Increased or improved access will increase the harvest of waterfowl.

Link 3: Increased harvest will lead to reductions in local populations of waterfowl.

HYPOTHESIS NO. 22

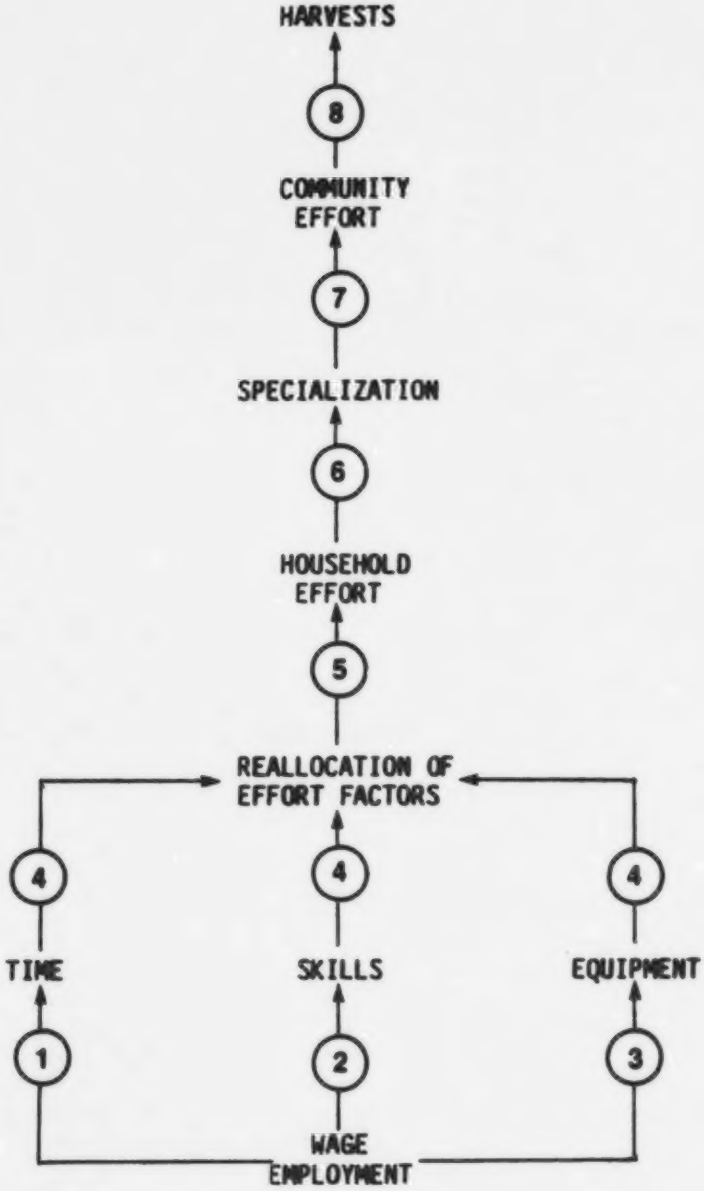
INCREASED LEVELS OF WAGE EMPLOYMENT WILL CHANGE THE TOTAL ANNUAL HARVEST OF RESOURCES BY COMMUNITIES IN THE REGION

For Hypothesis No. 22, the valued ecosystem components were mammals, birds and fish. Conclusions reached were that this hypothesis was invalid under present conditions. Information on present wage employment and harvesting practices was recommended to be obtained to provide baseline information.

The following material covers three project overviews relevant to this hypothesis.

HYPOTHESIS NO. 22

Increased levels of wage employment will change the total annual harvests of resources by communities in the region


HARVESTS
8
COMMUNITY EFFORT
7
SPECIALIZATION
6
HOUSEHOLD EFFORT
5
REALLOCATION OF EFFORT FACTORS
4
4
4
TIME
SKILLS
EQUIPMENT
1
2
3
WAGE EMPLOYMENT

LINKAGES

Link 1: Wage employment reduces the time available for harvesting.

Link 2: Wage employment decreases or delays opportunities to learn harvesting skills.

Link 3: Income from wage employment enables expansion and improvement of the supply of harvesting equipment.

Link 4: The allocation of effort employed by both individual units of production and related sets of units will change.

Link 5: Total effort on the part of individual and/or related sets of producing units will change.

Link 6: Substitution and reallocation of effort factors will affect both the numbers of producing units in a community and their degree of specialization.

Link 7: Specialization among producing units results in a reallocation of effort and a change in the total community harvesting effort.

Link 8: The level of effort is positively related to the volume of harvest.

MEMP PROJECT OVERVIEW NO. 22-1

TITLE:	Dene Gondie Study: Dene National perceptions of the impacts of the Norman Wells Project.
PRINCIPAL INVESTIGATORS:	W. Reese and P. Boothroyd
AFFILIATION:	Dene Nation, Canadian Wildlife Service
FUNDING SOURCE:	Government of Canada, through a contribution agreement with Dene Nation for the delivery of a Planning Support and Monitoring Program
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 22 and 24

BRIEF PROJECT OVERVIEW

The report documents Dene perceptions of Norman Wells Project impacts on individuals and communities in the Mackenzie Valley. The objectives of the post-construction study were to gather credible information about project impacts on communities; to provide better socio-economic planning information to communities, regional councils and the Dene Nation; to publish and publicize the Dene Norman Wells experience; and to provide research and analysis training to Dene. The study was conducted in 7 Mackenzie Valley communities. Fort Norman and Fort Good Hope are in the MEMP study area and are included in the Dene Gondie study. The study involved a team of researchers composed of local Dene and university students from southern Canada. Two survey questionnaires were administered to a sample of Dene residents and local Dene workers who worked on the Norman Wells Project.

The report compiles data on the Dene under the main categories of occupational status and traditional activities for the period immediately following completion of the construction. Of significance were the findings on occupational status: immediately following the Norman Wells Project, there was one third higher unemployment among the Dene than during the project. At the time of the survey, there was an even larger majority who were generally accepting or desirous of wage employment. Only a small percentage (18%), however, reported that they actually worked on the project. An even smaller group received institutional or on-the-job training while working on the project.

Other significant findings concerned traditional activities: the community survey determined that slightly over 50% of respondents had formerly been "week-end, part-time or full-time" trappers. During the post-construction survey period, 62% claimed that they did not trap any more. Those continuing to trap put less effort into the occupation, spending less time and putting out fewer traps. The reader is cautioned of a bias in the data resulting from the timing of the survey delivery.

Trapping conditions do not appear to have declined during the Norman Wells Project construction phase. There is no evidence in the report that trappers felt that the Norman Wells project had a negative effect on trapping. With respect to hunting, most interviewees suggested that they put less effort into hunting while successes only marginally declined. Respondents further suggested that the consumption of country food did not appear to have declined during the construction program.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Several of the hypotheses in the original MEMP report relate to the impact of industrial activities on the harvest of mammals, birds and fish. Impacts are suggested in land-use conflicts, and increased levels of wage employment bringing change to the total annual harvest. The Dene Gondie study relied on local knowledge and, as such, is seen as a credible study in the eyes of the Dene Nation.

Although the study was not a scientifically executed site-specific harvest study, it provides some definite insights. Of note is the status of the resource harvester immediately following the construction of a major resource development project, and the effects of land-use conflicts during project construction. Study data are particularly relevant to Hypotheses 22 and 24. The authors imply that direct cause and effect relationships of the Norman Wells Project require further study.

The report cautiously implies that in the relatively short duration of the Norman Wells Project construction, there may have occurred the beginning of a transition away from a social and economic system based on harvesting, to one based on wage employment. The report further implies that the overall impacts of a hydrocarbon development project on resource harvesting quality and harvester efforts are slight.

MEMP PROJECT OVERVIEW NO. 22-2

TITLE: Individual trapping - record summary.

PRINCIPAL INVESTIGATOR: R. Hall

AFFILIATION: Department of Renewable Resources (Fur Management), Government of the Northwest Territories

FUNDING SOURCE: Department of Renewable Resources

EXPECTED COMPLETION DATE: Ongoing

RELEVANT MEMP HYPOTHESIS: No.'s 22, 23 and 24

BRIEF PROJECT DESCRIPTION

The project is ongoing; fine-fur harvest data are currently being compiled for 1987. Summary reports provide an overview, by community, of the number of General Hunting Licence trappers who reported fur harvests to the Department of Renewable Resources. The report quantifies harvests of fine-fur species, and aggregate price by species. The data are summarized for each Government of Northwest Territories region and for the entire N.W.T. Standardized data reports are available for previous years.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The report provides a community-by-community database of annual fine-fur harvest. The data have been standardized over the years and annual comparisons demonstrating trends in the number of trappers, volumes by species and aggregate prices paid by species can now be made. The reports are relevant to Hypothesis 22, 23 and 24 in that they provide a historical profile of harvester activities in a temporal and spatial context.

MEMP PROJECT OVERVIEW NO. 22-3

TITLE:	Socio-economic monitoring report 1985, Norman Wells to Zama Pipeline project.
PRINCIPAL INVESTIGATOR:	Interprovincial Pipeline Ltd.
FUNDING SOURCE:	Interprovincial Pipeline Ltd.
COMPLETION DATE:	1985
RELEVANT MEMP HYPOTHESIS:	No. 22 and 24

BRIEF PROJECT OVERVIEW

The purpose of the 1985 monitoring report was to provide an end-of-construction review of socio-economic impacts of the Norman Wells to Zama Pipeline Project. The report provides a review of IPL's efforts to develop and implement appropriate impact management strategies and monitoring programs for the project. It also provides an overview of the impact management process.

The report comments on: the success of information and consultation with government and communities; direct benefits to northern business for the purchase of goods and services; regulatory and socio-economic orientation provided to project personnel; and the degree of northern employment and training resulting from the construction phase of the project.

A summary of concerns and opinions expressed by community informants are presented for Norman Wells, Fort Norman, Wrigley and Fort Simpson. In Norman Wells, an unquantified perception was that fewer people were trapping because of additional income available on project employment. A substantial amount of wages, however, were spent on new equipment such as skidoos, canoes and motors.

IPL's approach to the pipeline routing emphasized the prevention of potential conflicts and minimizing impacts on wildlife and the environment. The company developed and implemented a "Wildlife Harvesting Policy" to mitigate project impacts on local hunters and trappers. The policy, which was transmitted to local Hunter and Trappers Associations, outlined IPL's commitments towards: IPL/trapper relations, compensation for fur loss, compensation for equipment damages, cabin relocation assistance, right-of-way wildlife monitoring, and youth trapper training programs. Notification was given to trappers one month prior to construction activity. The effect was that just 4 compensation claims were made. Each was resolved to the satisfaction of the trappers involved and IPL.

IPL funded a wildlife monitoring program which was administered by a Hunters and Trappers Association. The monitoring reports supplemented by those of IPL's wildlife advisor and pipeline environmental inspectors, suggest that the effects of the pipeline construction on wildlife were quite limited.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The 1985 IPL socio-economic monitoring report presents information relevant to linkages in Hypothesis 22 and 24. Although considered invalid in the original MEMP report, the linkage regarding wage employment reducing the time available for harvesting is supported by IPL's socio-economic monitoring for Norman Wells. IPL monitoring confirmed that new equipment was being purchased which, it suggested, could possibly be used for future hunting and trapping activities.

HYPOTHESIS NO. 23

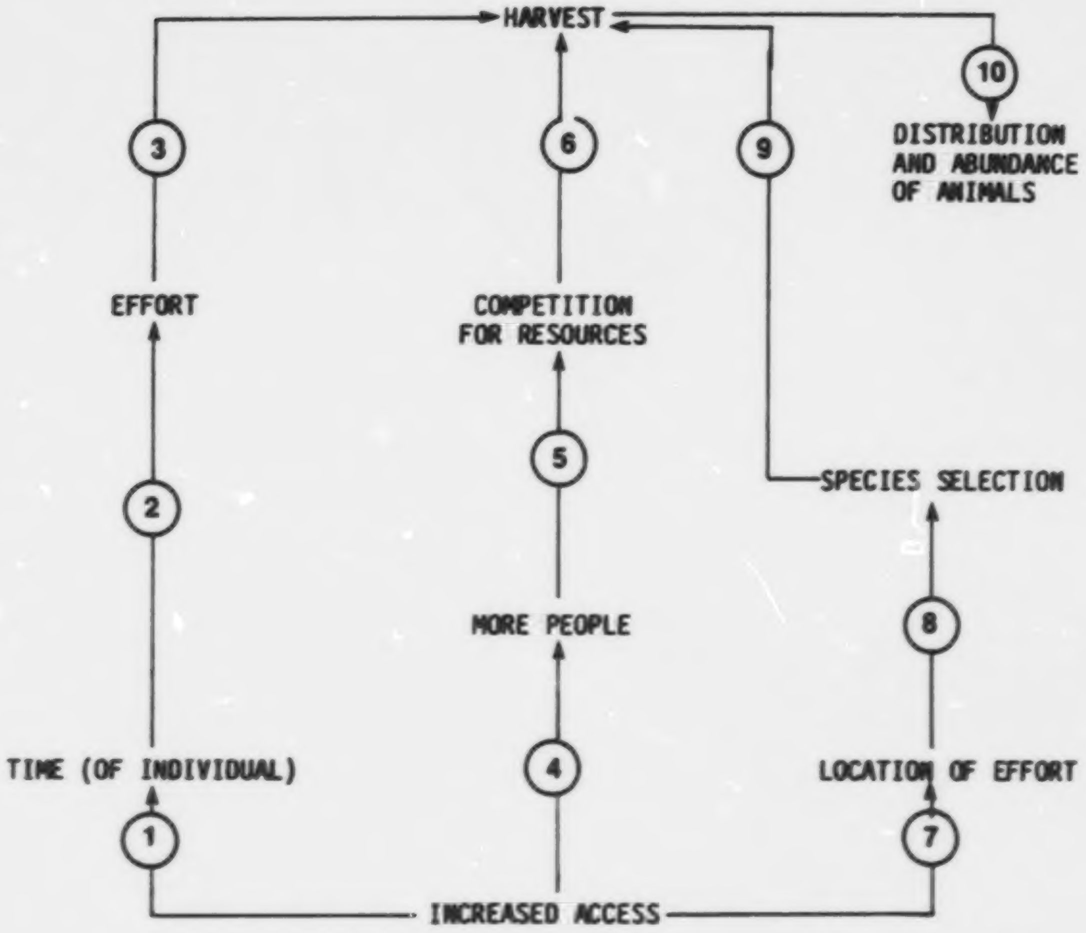
CHANGES IN ACCESS WILL ALTER THE HARVEST OF BIRDS, FISH AND MAMMALS

For Hypothesis No. 23, the valued ecosystem components were mammals, birds and fish. Conclusions reached were that this hypothesis was valid for mammals and fish, but unlikely for migratory birds. It was recommended that current harvests of mammals and fish be documented.

The following material covers two project overviews relevant to this hypothesis.

HYPOTHESIS NO. 23

Changes in access will affect the harvest of birds, fish and mammals



HARVEST
10
DISTRIBUTION AND ABUNDANCE OF ANIMALS
3
6
9
EFFORT
COMPETITION FOR RESOURCES
5
SPECIES SELECTION
2
MORE PEOPLE
8
TIME (OF INDIVIDUAL)
4
LOCATION OF EFFORT
1
7
INCREASED ACCESS

LINKAGES

Link 1: Changes in access will decrease the time spent in harvesting activities by an individual harvester.

Link 2: Decreases in travel time will affect the level of effort or catch per unit of effort.

Link 3: Changes in the level of effort will change harvests

Link 4: Increased access to an area results in increased use of the area.

Link 5: An increase in the number of people using an area for hunting and trapping will result in competition among them for limited resources.

Link 6: Competition for resources will affect harvests.

Link 7: Increased access changes the locations at which harvesting effort is applied

Link 8: Changes in the location of effort may result in changes in the species harvested.

Link 9: Changes in species selection will influence harvests.

Link 10: Harvest changes as a result of increased access may affect the distribution and abundance of animals locally or regionally.

MEMP PROJECT OVERVIEW NO. 23-1

TITLE:	Community renewable resource harvest maps.
PRINCIPAL INVESTIGATOR:	S. Matthews
AFFILIATION:	Department of Renewable Resources (Environmental Assessment), Government of the Northwest Territories
FUNDING SOURCE:	Norman Wells Environmental Impact Funding
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No.'s 23 and 24

BRIEF PROJECT DESCRIPTION

A digital, mapped database was produced for four Mackenzie Valley communities. Community field workers collected renewable resource harvesting information for general hunting licence holders. A composite community harvesting map contains the following information: base map - hydrology; relief - selected contours; exploration, development and transportation; species harvest - ungulates, fish, etc.; family trapping areas - species trapped and areas used; traplines - individual traplines, outpost camps, archaeological sites. The data were collected in 1985 and maps were produced in 1986.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The mapping project has little relevance to MEMP from either a community-specific or baseline data collecting perspective; the four communities mapped are outside the physical boundary of MEMP. The mapping project does, however, illustrate a process for deriving and displaying harvest and land-use data which is relevant to Hypotheses 23 and 24.

MEMP PROJECT OVERVIEW NO. 23-2

TITLE:	Porcupine caribou harvest by Canadian users progress report to the Porcupine Caribou Management Board June 1986 - December 1986.
PRINCIPAL INVESTIGATORS:	R. Quock and J. Carey
AFFILIATION:	Yukon Department of Renewable Resources
FUNDING SOURCE:	NOGAP
COMPLETION DATE:	1987
RELEVANT MEMP HYPOTHESIS:	No. 23

BRIEF PROJECT DESCRIPTION

Reported is the semi-annual estimated harvest of the Porcupine Caribou from all Canada. Measurements included species killed, sex and general age class, kill date and time, and location of the kill in relation to the Dempster Highway. Hunter data were derived from voluntary recall and hunter check stops. A data comparison to the previous reporting format reveals significant increases in hunter harvests. The differences are explained as a change in reporting format, i.e., 6 months in 1986 to 12 months in 1985, and the distributions of the Porcupine Caribou Herd in relationship to Aklavik, Fort McPherson, and the Dempster Highway during successive reporting periods.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

This report is relevant to Hypothesis 23 stating that changes in access will affect the harvest of birds, fish and mammals. With site-specific monitoring on the Dempster Highway, the data suggest that herd distribution and improved access will increase the harvest of caribou.

HYPOTHESIS NO. 24

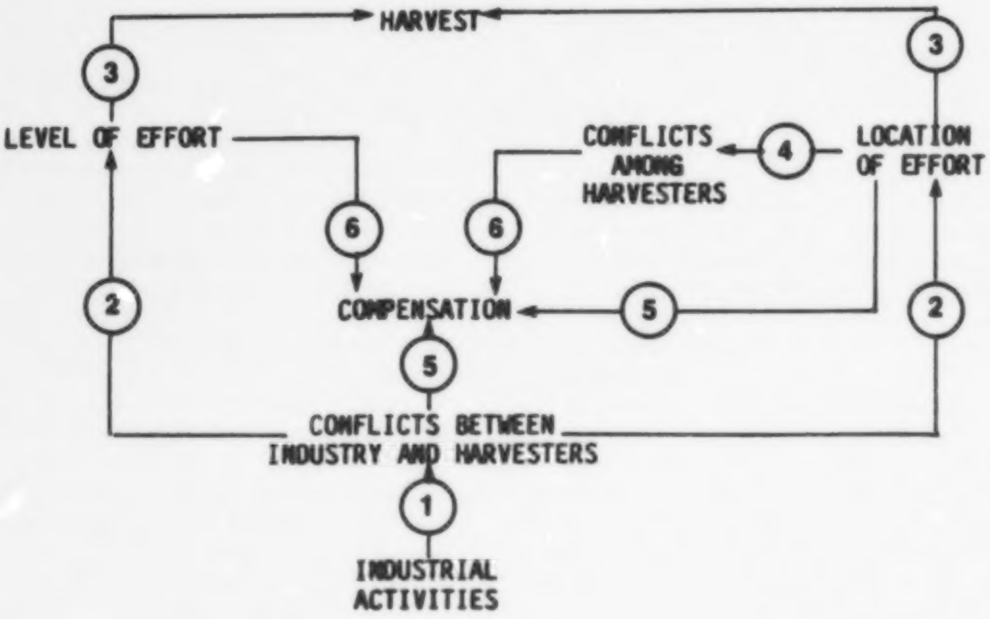
INDUSTRIAL ACTIVITIES IN HARVESTING AREAS WILL REDUCE THE HARVEST OF MAMMALS, BIRDS AND FISH BECAUSE OF CONFLICTS BETWEEN INDUSTRY AND HARVESTERS OVER LAND USE

For Hypothesis No. 24, the valued ecosystem components were mammals, birds and fish. Conclusions reached were that this hypothesis was possible at a local level, especially with respect to trapping. It was recommended that harvest and land use information be obtained.

The following material covers two project overviews relevant to this hypothesis.

HYPOTHESIS NO. 24

Industrial activities in harvesting areas will reduce the harvest of mammals, birds and fish because of conflicts between industry and harvesters over land use


HARVEST
3
3
LEVEL OF EFFORT
CONFLICTS AMONG HARVESTERS
4
LOCATION OF EFFORT
6
6
2
COMPENSATION
5
2
5
CONFLICTS BETWEEN INDUSTRY AND HARVESTERS
1
INDUSTRIAL ACTIVITIES

LINKAGES

Link 1: Industrial activities will result in conflicts between industry and harvesters.

Link 2: Conflicts between industry and harvester will result in the alienation of land from resource harvesting on a temporary or permanent basis.

Link 3: Changes in location and level of effort of some harvesters will reduce both individual and community harvests.

Link 4: Harvesters will move into someone else's harvesting area and come into conflict and compete with harvesters who are already using the area.

Links 5 & 6: All levels of conflict resulting from the exclusion of harvesting from specified areas will be compensated.

MEMP PROJECT OVERVIEW NO. 24-1

TITLE:	Dene mapping project (proprietary information).
PRINCIPAL INVESTIGATOR:	Dene Metis Negotiating Secretariat
AFFILIATION:	Dene/Metis Negotiating Secretariat, Dene Nation, University of Alberta (School of Native Studies)
FUNDING SOURCE:	Dene Nation
EXPECTED COMPLETION DATE:	1979 and ongoing
RELEVANT MEMP HYPOTHESIS:	No. 24

BRIEF PROJECT DESCRIPTION

The project presents trails, hunting areas, traplines, fishing areas and extent of traditional land in the Mackenzie Valley between 1885 and 1979, on computerized maps. The data were derived from the traditional knowledge of a sample of living Dene between 1972 and 1979. The mapping project is considered proprietary information for the Dene/Metis land claim.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

As a historical database of traditional land use by the Dene/Metis of the Mackenzie Valley, its relevance as a negotiating tool could be particularly important to the Dene in the settlement of industry/harvester land use conflicts. Hypothesis 24 concludes that conflicts/impacts are possible and that both harvest and land use information should be available to support compensation claims. The mapping project provides the historical overview to such claims.

MEMP PROJECT OVERVIEW NO. 24-2

TITLE: An evaluation of the Norman Wells Project by the Department of Renewable Resources, Government of the Northwest Territories.

PRINCIPAL INVESTIGATORS: S.B. Matthews and R.M. Larson

AFFILIATION: Policy and Planning Division, Department of Renewable Resources, Government of the Northwest Territories

FUNDING SOURCE: Department of Renewable Resources

COMPLETION DATE: 1987

RELEVANT MEMP HYPOTHESIS: No.'s 24 and 25

BRIEF PROJECT DESCRIPTION

The evaluation was conducted to assess the effectiveness of the department's participation in the public and regulatory review processes; assess departmental effectiveness in project and impact management; to assess the overall review process with respect to DIAND, NEB and IPL involvement; to provide recommendations for the Department's participation in future large-scale development projects; and to provide recommendations on improving the public and regulatory review processes.

The report reviews departmental activities relating to project and impact management. Key issues are noted and recommendations presented. The department's involvement in wildlife management along the pipeline right-of-way and at the Norman Wells construction site, and its support of hunters and trappers were considered in the report. During the construction phase of the project, it was cited that wildlife/human interactions were few and road kills were considered minimal. As a result of an effective deterrent program, the recorded number of nuisance black bears destroyed by departmental officers was reduced considerably.

Hunting pressure increased in the Norman Wells area as completion of the oilfield expansion project approached. The number of resident sport hunting licenses sold during the construction years (1983 and 1984) nearly doubled that of the 3 previous years. The resident hunter moose harvest demonstrated a two-fold increase in 1984 and it was suggested that General Hunting Licence harvesters experienced a similar increase. Trapper compensation policies for the Norman Wells Project were developed by both the Government of the Northwest Territories and IPL. Three compensation claims were filed and, in two other situations, individuals met with IPL to discuss hunting and trapping concerns. The claims were settled quickly and to the satisfaction of all parties involved. The report recommends that government must encourage community participation in developing compensation plans for development projects.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

Given that the Norman Wells Project represents the first and largest development project in the Mackenzie Valley, the lessons learned will be significant in future development projects. The evaluation undertaken by Renewable Resources provides additional information relevant to linkages in Hypotheses 24 and 25. Compensation claims did result from conflicts but were site specific and resolved to the mutual satisfaction of those involved. This supports the linkages in Hypothesis 24.

The wildlife harvest information in Norman Wells supports the linkages that development will result in an increase of non-local and native migrants. The further result will be increased demand for fish and wildlife as suggested in Hypothesis 25.

HYPOTHESIS NO. 25

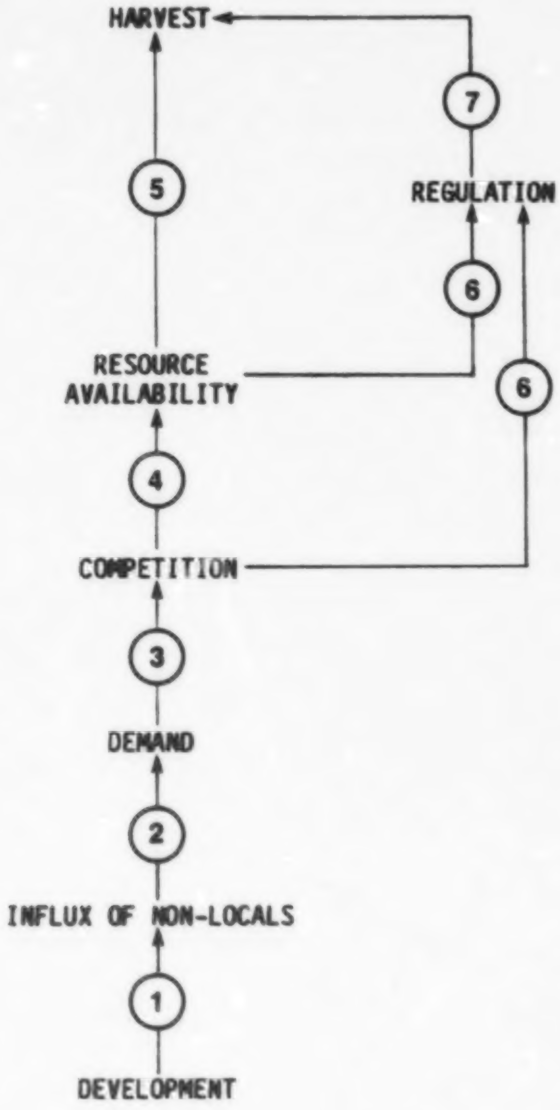
INCREASES IN HUNTING BY NON-LOCALS WILL RESTRICT HARVEST BY LOCAL NATIVES

For Hypothesis No. 25, the valued ecosystem components were mammals, birds and fish. Conclusions reached were that this hypothesis was valid under present conditions. It was recommended that non-local harvests and native harvest for selected species be documented. Animal population studies were also recommended.

The following material covers two project overviews relevant to this hypothesis.

HYPOTHESIS NO. 25

Increases in hunting by non-locals will restrict harvests by local natives


HARVEST
7
5
REGULATION
6
RESOURCE AVAILABILITY
6
4
COMPETITION
3
DEMAND
2
INFLUX OF NON-LOCALS
1
DEVELOPMENT

LINKAGES

Link 1: Development will result in influx of non-locals.

Link 2: Influx of non-locals will result in increased demand for fish and wildlife.

Link 3: Increased demand will result in increased effort and competition among harvesters.

Link 4: Increased competition will result in decreased local resource abundance.

Link 5: Increased harvesting effort by non-locals and/or decreased local resource availability will result in reduced local native harvests and/or reduced catch per unit effort.

Link 6: Increased competition and/or decreased resource availability will lead to restrictions on local native harvests.

Link 7: Regulation of harvest will restrict native harvests.

MEMP PROJECT OVERVIEW NO. 25-1

TITLE:	Summary of 1984/85, 1985/86, 1986/87 Resident Hunter Harvest Survey.
PRINCIPAL INVESTIGATORS:	R. Graf and D. Grant-Francis
AFFILIATION:	Department of Renewable Resources, Government of the Northwest Territories
FUNDING SOURCE:	Government of the Northwest Territories
EXPECTED COMPLETION DATE:	Ongoing
RELEVANT MEMP HYPOTHESIS:	No. 25

BRIEF PROJECT DESCRIPTION

This is an ongoing program of the wildlife division of the Department of Renewable Resources. The program enables the collection and reporting of annual non-native resident hunter harvest data for selected species by community and region. Annual reports break out non-native resident hunter harvest of upland game birds and barren ground caribou.

Data are also collected on location of harvest and some demographics of the harvester. Non-native resident hunters are licenced and regulated under a different system than native General Hunting Licence holders. A non-native resident hunter must have resided in the Northwest Territories for a defined time period prior to the issue of the resident hunting licence.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

In its present form the report is not directly related to the increased non-local demand and competition for fur, fish and game resources. The questionnaire, however, collected enough information to track non-native resident hunter harvest and provide baseline information to the hypothesis in a temporal and spatial setting.

MEMP PROJECT OVERVIEW NO. 25-2

TITLE:	Norman Wells socio-economic impact monitoring report, Summary Report 1-86. Changes in country food consumption, Report 3-85. Population impacts of the Norman Wells Project on the four study communities 1982-1984, Report 2-85.
PRINCIPAL INVESTIGATORS:	D.A. Stewart and R.M. Bone
AFFILIATION:	Department of Geography, University of Saskatchewan
FUNDING SOURCE:	Indian Affairs and Northern Development
COMPLETION DATE:	1986
RELEVANT MEMP HYPOTHESIS:	No. 25

BRIEF PROJECT DESCRIPTION

The monitoring program was designed to identify impacts of the Norman Wells Project in three main phases - pre-construction, construction and post-construction. The major socio-economic findings of the monitoring program are extracted from a series of 26 reports and summarized. The major impacts are identified as: demographic impacts, impacts on the activity of household members, impacts on income in the region, impacts on consumer spending patterns, impacts on country food consumption, impacts on perceptions about jobs and development, perceived social impacts, employment impacts, and business impacts.

In conclusion, the report states that assessing the success of the Norman Wells Project from the view of the monitoring program has been a case of over-expectation. Local residents did not receive as many jobs or increases in their income as some northerners had expected, while the influx of southerners was much lower and the disruption to traditional activities and native culture was less than stated in predictions at the public assessment phase of the project. Overall, the benefits to the local residents from the Norman Wells Project were less than they expected, but the social costs were also lower than some predicted.

RELATIONSHIP AND RELEVANCE TO THE MACKENZIE ENVIRONMENTAL MONITORING PROJECT

The authors argue that any change in traditional activities of hunting and trapping by residents in Fort Norman, Norman Wells, Wrigley and Fort Simpson should reflect itself in their consumption of country foods. During construction the consumption of country foods increased in the four communities. The shift occurred in those family units which previously did not use much country food in their diets. Those households which used a high amount of country foods remained constant throughout the construction phase of the project.

Among native residents of the four communities, country food consumption did not change significantly. Bone and Stewart concluded that increased involvement in the wage economy during the Norman Wells Project did not reduce the level of consumption of country food. Their findings suggest that the short-term effect of industrial activity on food harvesting will generate overall benefits to the entire population with little specific benefit to the native population. The report does not, however, look at long-term implications of this overall benefit on the native subsistence harvesting units.

The summary report provides a baseline for ongoing monitoring of the long-term impact from industrial development on harvesting activities. Further monitoring would be useful in testing Hypothesis 25 which links increases in hunting by non-locals to a reduction in harvests by local natives. The implementation of a moose management plan in the Mackenzie Valley and the attendant regulation of all harvesting activity could verify linkages in Hypothesis 25.

PART III

RECOMMENDATIONS FOR NEW HYPOTHESES OR REVISIONS OF CURRENT HYPOTHESES AND MONITORING PROGRAMS

Table 3 and accompanying text summarizes recommendations concerning possible revisions of current biophysical hypotheses and possible needs for new biophysical hypotheses. The recommendations are based on reviews of current literature and research and on discussions with investigators active in the MEMP study area. Tables 4, 5 and 6 and accompanying text summarize the recommendations concerning possible revisions of current resource harvesting hypotheses and resource harvesting monitoring programs.

A brief rationale is given for each suggested change or revision. However, the actual task of revising hypotheses or constructing new hypotheses or monitoring programs is not within the scope of this phase of MEMP. Such changes would best be made through a more formal and structured process involving a broader complement of participants.

Biophysical Hypotheses: No.'s 1-17

Hypothesis 2: Traffic and Caribou

A review of the recent literature pertaining to the effects of roads and traffic on caribou and to the seasonal distribution of the Porcupine herd in relation to the proposed North Slope roads indicates a possible need for extensive revisions of Hypothesis 2.

Links 4 (reduced access to insect relief habitat will increase the incidence of parasites and reduce the quality of caribou hides) and 5 (decreased animal fat levels will reduce the quality of caribou meat and hides) are speculative and dependent on several questionable assumptions. The quality of meat and hides is dependent of a variety of environmental and physiological factors, most of which appear to be independent of the potential effects of roads or traffic. The relationship between traffic and energetics of caribou, the weaker link between energetics and meat or hide quality should be reassessed based on recent information (e.g., Project Overview No. 2-19).

The need for a new link on the effects of legal and illegal hunting from new and existing access roads should be assessed since such effects are known to result in significant impacts on other caribou herds in North America. This linkage could be a major omission in the original presentation of Hypothesis 2.

Hypothesis 4: Water Level and Muskrats

Published information suggests that an additional link (Link 7A) should be added to account for increased predation on muskrats by mink at low water levels. However, the conclusions of the 1986 MEMP working group were that the water levels in the study area where muskrat densities are high would not be significantly affected by development. Therefore, the entire hypothesis appears to be invalid and minor revisions as indicated would not result in acceptance of the hypothesis.

Table 3. Recommendations for revisions of existing MEMP biophysical hypotheses (1-17) and needs for new hypotheses.

Hypothesis Number	Number of Links	Subject of Hypothesis	Revision of Hypothesis	New Hypothesis
1	10	Garbage, Habitat and Foxes	No	No
2	10	Traffic and Caribou	Yes	No
3	7	Garbage, Habitat and Grizzly Bears	No	No
4	12	Water Levels and Muskrats	Yes	No
5	8	Habitat Changes and Moose	Yes	No
6	10	Habitat Changes and Marten	No	No
7	13	Disturbance and Waterfowl	No	No
8	9	Disturbance and Raptors	No	No
9	3	Predators and Waterfowl	No	No
10	4	Oil and Waterfowl	No	No
11	8	Subsidence, Water Levels, Fish and Wildlife	No?	No
12	1	Emissions and Air Quality	No	No
13	2	Disturbance and Quality of Fish	No	No
14	4	Improved Access and Fish	Yes	No
15A,B	5,13	Discharges, Water Quality and Fish	No	No
16	16	Linear Corridors and Fishing Success	No	No
17	1	Garbage and Wolverines	No	No

Hypothesis 5: Habitat Changes and Moose

Several revisions appear to be warranted for this hypothesis based on recent studies. There are also some conflicting statements regarding the validity of links in the 1986 MEMP report. Food quality is likely to be of greater importance than food quantity. This factor should be reflected in Link 1 (clearing vegetation will increase the amount of moose food). Link 1 must also be qualified to include primarily forested areas. Seismic operations in tundra areas have been shown to have a negative impact on total vegetation available on seismic lines.

Link 5 (above-ground pipelines will alter moose migration patterns) assumes that an above-ground pipeline will prevent the passage of moose and lead to changes in migratory movements. Recent information indicates moose that are sufficiently motivated to cross a pipeline (e.g., migrating) will do so regardless of the physical characteristics of the pipeline. Therefore, Links 5, 6 (energy balance determines reproductive success of adult moose) and 7 (reproductive success determines the size of the moose population) need to be modified to reflect the low potential for moose migration patterns to be affected by above-ground pipelines.

Hypothesis 11: Land Subsidence

A considerable amount of uncertainty was evident in discussions of the working group that formally considered the effects of indirect land subsidence on fish, waterfowl and muskrat. As discussed in INAC et al. (1986) there is presently no reliable method to accurately predict reservoir compaction and direct subsidence. This, coupled with the uncertainty in relation to indirectly-inducted subsidence caused by changes in permafrost and ground ice, makes any conclusions reached extremely tentative. For these reasons, it may be beneficial to reexamine the issue of induced subsidence at periodic intervals.

Hypothesis 14: Improved Access and Fish Harvest

Hypothesis 14 at the present time only considers effects of exploitation on fish distribution and abundance. Thought should be given to revising the hypothesis to also consider effects of harvests on fish quality. Typically, initial harvest efforts concentrate on the largest individuals available for capture. This is true in both sport and domestic/commercial fisheries. As a result, progressively smaller individuals are available for capture in subsequent fishing efforts. Thus, mean size of fish in heavily fished populations may decrease significantly. This in turn could alter present (and future) fishing patterns. This effect should also be considered in resource harvesting Hypothesis 23.

Resource Harvesting Hypotheses: No.'s 18-25

Background

Before defensible resource harvesting hypotheses were developed, a model of the impact of industrial development on native resource harvesting needed to be constructed (INAC et al. 1986: 218-231). The main components of this model, as applied to Hypotheses 18-25, were as follows:

1. wage employment;
2. effort;
3. harvest;
4. mutual aid/sharing;
5. access;
6. competition between harvesters;
7. resource base (distribution and abundance of mammals, birds and fish);
8. conflict between industrial activity and harvesters; and
9. compensation.

Monitoring of each of the components was recommended for one or more of the original hypotheses (Table 4).

Native people from the communities in the Mackenzie Valley, the Great Bear Region, the Mackenzie Delta, and along the Beaufort Sea had a strong influence on the resource harvesting aspects of MEMP, and on the development of the impact hypotheses. Throughout the project, two points were stressed by native participants: 1) the communities wished to be involved in any monitoring that was undertaken; and 2) communities viewed resource harvesting to be species specific and to be directly oriented to the community. Taken together, these points argue for monitoring programs which have community involvement and which focus on the local abundance of animals. A blending of this sociological need with scientifically defensible monitoring programs is a major objective of the resource harvesting portion of MEMP.

Overview of Project Summaries

To provide a basis for our evaluation of project overviews that are relevant to the MEMP resource harvesting hypotheses, each project was reviewed to determine which of the major components (listed earlier) of resource harvesting hypothesis were addressed. In addition, the projects were evaluated to determine whether they were: 1) community based; and 2) whether monitoring was based on the local abundance of animals.

A brief analysis (Table 5) of the approximately 30 project summaries shows that most recent monitoring and research appears to have been concentrated on harvest components (8 of 20) and the wage employment component (5 of 20). Most of the other components have been somewhat neglected. Effort (as a component) was addressed in 4 of 20 projects but the focus was primarily on the location of effort in 3 of the 20 studies; all 3 studies were related to the Dene Nation and/or the community of Fort Good Hope. Monitoring of local abundance of resources apparently has not been reported. In view of the importance of this type of monitoring, future work needs to be directed in this area.

Revisions to Monitoring Programs

In the evolution of MEMP, the development of the resource harvesting hypotheses lagged behind the development of the biophysical hypotheses. As a consequence, the final monitoring recommendations for the resource harvesting hypotheses have been less well defined compared to the biophysical hypotheses. For example, the monitoring recommendations for Hypotheses 22-25 were in general to provide detailed direction to prospective monitoring projects. Furthermore, many of the original monitoring studies were designed and undertaken independent of each other, and therefore addressed different objectives. Thus, we recommend that these hypotheses be revised somewhat (Table 6) to more closely reflect community-specific and species-specific concerns.

Revisions to Hypotheses

The present study team did not reach a unanimous conclusion regarding the need for revision of Hypothesis 22 - effects of wage employment on harvesting. One view was that the hypothesis should be revised and made more specific. An opposing view was that some of the conclusions made in recent studies are tentative, speculative or that data is open to different interpretations, hence the hypothesis should not be revised. This difference in opinion clearly demonstrates the need for a critical examination of all links in Hypothesis 22 and re-evaluation of conclusions and recommended research and monitoring programs. Projects such as those reviewed in Project Overviews 18-6 and 18-7 and 22-1, 22-2 and 22-3 are especially relevant to Hypothesis 22.

The Mismatch of Biophysical Hypotheses and the Resource Harvesting Hypotheses

A careful review of the biophysical hypotheses (1-17) shows that they are for the most part species-specific, and are focused on regional impacts. However, the resource harvesting hypotheses (18-25), with the exception of those for white whales, are not species-specific and are more concerned about impacts on the communities. Similarly, most of the fish- and wildlife-related hypotheses appear to be related more to general population-level effects on resources, rather than to local community effects, even though such local effects are of prime concern to communities. This mismatch between the two types of hypotheses suggests that a different view must be taken if progress is to be made in the monitoring of resource harvests. To understand the effects of oil and gas development on resource harvesting, we must monitor the activities of the resource harvester, as well as the local changes in distribution and abundance of species and local populations of resources near the communities.

Table 4. A summary of the 9 major components that are addressed in each resource harvesting hypothesis (x). Those components for which monitoring was originally recommended are denoted by 'o'.

	Hypotheses							
Components	18	19	20	21	22	23	24	25
Wage Employment	o				o			
Effort	x	x	x		o	o	o	
Harvest	o	o	x	x	o	o	o	o
Mutual Aid/Sharing					o			
Access				x		o		
Competition			x			o		o
Resource Base	o			x	x		x	o
Conflict							o	
Compensation							o	

Table 5. The number of overviews (projects) that address each of the 9 major components of the resource harvesting hypotheses. Two additional important components have been included*.

Component	Number of Studies
Wage Employment	5
Effort	4
Harvest	8
Mutual Aid/Sharing	0
Access	1
Competition	2
Resource Base	0
Conflict	3
Compensation	2
Community Involvement*	3
Local Abundance*	0

Table 6. Recommended revisions to Hypotheses 18-25 and associated monitoring programs.

Hypothesis Number	Number of Links	Subject of Hypothesis	Revision of Hypothesis	Revision of Monitoring
18	10	Wage employment and white whale harvest	no	no
19	2	Vessels and white whales	no	no
20	5	Increased hunting and white whales	no	no
21	3	Increased access and white whales	no	no
22	8	Wage employment and increased harvest	possibly	yes
23	10	Increased access and wildlife harvest	no	yes
24	6	Land-use conflicts and wildlife harvest	no	yes
25	7	Non-local vs. local harvest conflicts	no	yes

LITERATURE CITED

Beanlands, G.E. and P.N. Duinker. 1983. An ecological framework for impact assessment in Canada. Halifax: Institute for Resource and Environmental Studies. 132 p.

Cordes, L.D., D. McLennan and C.M. Pearce. 1984. Alluvial ecosystems on the Mackenzie Delta, N.W.T. B.C. Hydro Research Contract, Environment and Socio-Economic Division, Vancouver, B.C.

Cordes, L.D. and D. McLennan. 1984a. Phenology of vegetation in the Mackenzie Delta area, 1981 and 1982. B.C. Hydro Research Contract, Environment and Socio-Economic Division, Vancouver, B.C. 71 p. plus appendices.

Cordes, L.D. and D. McLennan. 1984b. Bathymetry and morphometry of 32 Mackenzie Delta lakes. B.C. Hydro Research Contract, Environment and Socio-Economic Division, Vancouver, B.C. 33 p. plus appendices.

Cordes, L.D. and D. McLennan. 1984c. The distribution of aquatic macrophytes in the lakes of the Mackenzie Delta. B.C. Hydro Research Contract, Environment and Socio-Economic Division, Vancouver, B.C. 51 p. plus appendices.

Cordes, L.D. and D. McLennan. 1984d. The determination of sedimentation rates using 137Cs in lakes of the Mackenzie Delta. B.C. Hydro Research Contract, Environment and Socio-Economic Division, Vancouver, B.C.

Cordes, L.D. and C.M. Pearce. 1979. Vegetation change on the Peace-Athabasca Delta: 1977-1978. Parks Canada Research Contract 585/78-70, Indian and Northern Affairs, Winnipeg, Manitoba. 76 p. plus appendices.

Everitt, R., D.A. Birdsall and D.P. Stone. 1985. Beaufort Environmental Monitoring Project. Proc. Conf. Northern Hydrocarbon Development, Environmental Problem Solving - International Society of Petroleum Industry Biologists. September 24-26 1985, Banff Alberta.

Forbes, D.L. 1985. Coastal erosion and sedimentation in the Canadian Beaufort Sea. In: Current Research, Part C, Geological Survey of Canada, Paper 85-1B, pp 69-80.

Gill, D. 1973a. Modification of northern alluvial habitats by river development. The Canadian Geographer, xvii,2:138-153.

Gill, D. 1973b. Floristics of a plant succession sequence in the Mackenzie Delta, N.W.T. Polarforschung 43:55-65.

Gill, D. 1972. Modification of levee morphology by erosion in the Mackenzie River Delta, N.W.T., Canada. The Institute of British Geographers, No. 4:123-136.

Gill, D. 1971. Vegetation and environment in the Mackenzie Delta, N.W.T.: a study in subarctic ecology. Ph.D. thesis, Department of Geography, University of British Columbia, Vancouver, B.C. 694 p.

Holling, C.S. (ed.). 1978. Adaptive environmental assessment and management. Chichester: Wiley & Sons.

Indian and Northern Affairs Canada and Environment Canada. 1984. Beaufort Environmental Monitoring Project 1983-84 Final Report. Unpubl. Rep. by LGL Limited, ESL Environmental Sciences Limited and ESSA Limited. 292 p.

Indian and Northern Affairs Canada and Environment Canada. 1985. Beaufort Environmental Monitoring Project 1984-85 Final Report. Unpubl. Rep. by ESL Environmental Sciences Limited, LGL Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 162 p.

Indian and Northern Affairs Canada. 1986. Beaufort Environmental Monitoring Project 1985-86 Final Report. Unpubl. Rep. by LGL Limited, ESL Environmental Sciences Limited, ESSA Limited, Arctic Laboratories Limited and Arctic Sciences Limited. 199 p.

Indian and Northern Affairs Canada, Environment Canada, Fisheries and Oceans Canada, Government of the Northwest Territories and the Yukon Territorial Government. 1986. Mackenzie Environmental Monitoring Project 1985-86 Final Report. Unpubl. Rep. by LGL Limited, ESL Environmental Sciences Limited, Essa Environmental and Social Systems Analysts Ltd., and P.J. Usher Consulting Services Limited. 308 p. + Appendices.

Lapointe, M.F. Patterns and processes of channel change, Mackenzie Delta, N.W.T. 1983-84 progress report.

Lapointe, M.F. 1985. Aspects of channel bathymetry and migration patterns in the Mackenzie Delta, N.W.T.

Marsh, P. 1985. Mackenzie Delta., lake hydrology progress report. Rep. by Cold Regions Section, Nat. Hydrology Res. Inst., Environ. Can.

Owens, R.A. 1985. Hydrocarbon development summary and scenario for a Mackenzie environmental monitoring program. Rep. by R.A. Owens Environmental services Limited and LGL Limited for Indian and Northern Affairs, Canada.